Table 2. UPDATE Table for the Blyth-Cadell Rivers System showing the 2-3', 3-4', and 4-5' size classes grouped together (2-5') and the size classes above those in another group (≥5'). We have also grouped the crocodiles sighted into small (2-6') and large (≥6').

Survey	Totals	Hatchlings	2-5'	≥5'	Small 2-6'	Large ≥6'	3-6'	Small/Large
26 October 74	387	89	286	12	292	6	211	48.7
1 November 75	353	50	263	40	289	14	183	20.6
MAJOR FLOODING								
23 September 76	348	82	221	45	240	26	177	9.2
4 November 76	307	61	217	29	230	16	169	14.4
11 April 77	327	72	230	25	242	13	172	18.6
3 May 77	333	88	215	30	231	14	171	16.5
8 June 77	365	108	215	42	232	25	196	9.3
16 September 77	386	105	234	47	257	24	212	10.7
23 October 77	360	112	204	44	226	22	158	10.3
10 June 78	432	173	219	40	238	21	173	11.3
12 September 78	399	155	200	44	221	23	161	9.6
NO FLOODING								
10 June 79	465	123	251	91	287	55	196	5.2
4 October 80	400	119	220	61	249	32	160	7.8

Table 2. (continued)

Survey	Totals	Hatchlings	2-5'	≥5'	Small 2-6'	Large ≥6'	3-6'	Small/Large
HEAVY FLOODING								
9 July 81	366	76	223	67	253	37	167	6.8
19 October 81	315	72	179	64	204	39	127	5.2
DRY WET--MINOR FLOODING ONLY								
25 June 82	408	136	166	106	205	67	163	3.1
6 November 82	347	111	164	72	197	39	154	5.1

LIVERPOOL-TOMKINSON RIVERS SYSTEM

Summary Table for the overall Liverpool-Tomkinson rivers System (Monograph 7)

18 July 76	248	19	152	77	180	49	141	3.7
25 May 77	245	40	129	76	166	39	160	4.3
27 October 77	228	56	118	54	147	25	140	5.9
27 September 78	233	37	131	65	156	40	138	3.9

Table 2. (continued)

Survey	Totals	Hatchlings	2-5'	≥5'	Small 2-6'	Large ≥6'	3-6'	Small / Large
		NO FLOODING						
16 July 79	515	289	109	117	152	74	141	2.1
19 October 79	355	161	101	93	136	58	120	2.3
15 October 80	295	71	136	88	173	51	122	3.4
		HEAVY FLOODING						
2 July 81	256	26	145	85	176	54	124	3.3
5 October 81	254	34	134	86	166	54	133	3.1
		DRY WET--MINOR FLOODING ONLY						
12 June 82	467	193	161	113	207	67	178	3.1
16 October 82	384	144	135	105	171	69	155	2.5

Table 3. Summary Table showing for each survey of the overall Blyth-Cadell Rivers System the number of crocodiles in the size classes indicated. The EO classes have been added together in each survey and 50% of these have been distributed equally among the 3-4', 4-5' and 5-6' size classes; the remaining 50% have been distributed to the ≥6' size classes with 1/3 being allocated to the 6-7' size class and 2/3 to size classes ≥7'. This weights the distribution heavily in favour of larger crocodiles, which are known to normally be the most wary. For 1974, all EO crocodiles were put in the ≥7' size class.

	Totals	H	≥2'	≥3'	≥4'	≥5'	≥6'	≥7'	km Surveyed	Density
26 October 74	387	89	298	217	70	12	6	4	91.9	3.24
1 November 75	353	50	303	197	114	40	14	7	94.9	3.19
				MAJOR FLOODING						
23 September 76	348	82	266	203	95	45	26	15	92.0	2.89
4 November 76	307	61	246	185	79	29	16	6	92.0	2.67
11 April 77	327	72	255	185	75	25	13	9	92.0	2.77
3 May 77	333	88	245	185	88	30	14	7	92.0	2.66
8 June 77	365	108	257	221	115	42	25	11	90.5	2.84
16 September 77	386	105	281	236	99	47	24	15	90.5	3.10
23 October 77	360	112	248	180	94	44	22	10	90.5	2.74
10 June 78	432	173	259	194	110	40	21	11	90.5	2.86
12 September 78	399	155	244	184	103	44	23	12	90.5	2.70

Table 3. (continued)

	Totals	H	≥2'	≥3'	≥4'	≥5'	≥6'	≥7'	km Surveyed	Density
NO FLOODING										
10 June 79	465	123	342	251	154	91	55	35	94.5	3.82
4 October 80	400	119	281	192	115	61	32	17	92.9	3.02
HEAVY FLOODING										
9 July 81	366	76	290	204	115	67	37	20	90.1	3.22
19 October 81	315	72	243	166	101	64	39	18	89.2	2.70
DRY WET--MINOR FLOODING ONLY										
25 June 82	408	136	272	230	163	106	67	37	91.9	2.96
6 November 82	347	111	236	193	123	72	39	19	92.5	2.55

EQUIVALENT TABLE FOR LIVERPOOL-TOMKINSON SYSTEM

18 July 76	248	19	229	190	119	77	49	30	158.9	1.44
25 May 77	245	40	205	199	142	76	39	19	145.1	1.41
27 October 77	228	56	172	165	121	54	25	11	123.4	1.39

Table 3. (continued)

	Totals	H	≥2'	≥3'	≥4'	≥5'	≥6'	≥7'	km Surveyed	Density
27 September 78	233	37	196	178	136	65	40	20	141.4	1.39
NO FLOODING										
16 July 79	515	289	226	215	168	117	74	37	150.0	1.51
19 October 79	355	161	194	178	136	93	58	35	141.1	1.38
15 October 80	295	71	224	173	128	88	51	31	140.6	1.59
HEAVY FLOODING										
2 July 81	256	26	230	178	122	85	54	31	140.6	1.64
5 October 81	254	34	220	187	129	86	54	32	141.1	1.56
DRY WET--MINOR FLOODING ONLY										
12 June 82	467	193	274	245	172	113	67	35	141.1	1.94
16 October 82	384	144	240	224	166	105	69	38	141.1	1.70

Table 4. Number of C. porosus sighted within the hatchling, small and large size classes on the three major components of the Blyth-Cadell Rivers System: Blyth mainstream, Blyth sidecreeks and Cadell River.

	Blyth Mainstream			Blyth Sidecreeks			Cadell			Totals		
	H	S	L	H	S	L	H	S	L	H	S	L
26 October 74	41	207	6	1	3	0	47	82	0	89	292	6
1 November 75	41	177	11	3	11	2	6	101	1	50	289	14
MAJOR FLOODING												
23 September 76	48	159	14	2	16	5	32	65	7	82	240	26
4 November 76	40	142	10	3	16	1	18	72	5	61	230	16
11 April 77	65	142	6	3	17	3	4	83	4	72	242	13
3 May 77	74	144	10	0	15	3	14	72	1	88	231	14
8 June 77	88	129	19	2	23	4	18	80	2	108	232	25
16 September 77	75	164	19	2	18	2	28	75	3	105	257	24
23 October 77	76	136	14	3	15	2	33	75	6	112	226	22
10 June 78	136	148	14	1	21	4	36	69	3	173	218	21
12 September 78	115	130	15	1	17	1	39	74	7	155	221	23
NO FLOODING												
10 June 79	85	171	40	1	15	9	37	101	6	123	287	55

Table 4. (continued)

	Blyth Mainstream			Blyth Sidecreeks			Cadell			Totals		
	H	S	L	H	S	L	H	S	L	H	S	L
4 October 80	86	139	22	0	16	4	33	94	6	119	249	32
HEAVY FLOODING												
9 July 81	48	144	27	2	25	3	26	84	7	76	253	37
19 October 81	37	127	28	3	13	2	32	64	9	72	204	39
DRY WET--MINOR FLOODING ONLY												
25 June 82	84	118	41	1	14	6	51	73	20*	136	205	67*
6 November 82	55	116	26*	0	9	3	56	71	11*	111	197	39

*Bias to large

recovery phase and towards eventual equilibrium conditions. Presumably at that stage there would be certain broad steady state ratios between the number of animals in the various size classes. These ratios could be expected to be system dependent.

Our data have revealed a number of unexpected features. One of these is the surprisingly long period of time that it has taken for the population to even show signs of an increase. C. porosus in the Northern Territory has not been hunted legally since 1971, and one might be tempted to assume that the population would surely have recovered to much high numbers during the intervening 11 years. Even a brief study of Table 9.2.1 in Monograph 1 (covering some 100 tidal waterways in northern Australia) and Tables 1 to 3 in the present paper shows that it has not, and furthermore that any major sustained increase can be expected to be measured in terms of decades (Monograph 1, Addendum, p. 445).

The Blyth-Cadell and Liverpool-Tomkinson Systems are among the best TYPE 1 tidal waterways for C. porosus in northern Australia. However, while 292 small and 6 large crocodiles (Table 3) were sighted on the Blyth-Cadell System during the October 1974 survey (the results for the November 1975 survey were much the same), on the June 1982 survey only 205 small and 67 large crocodiles were sighted. It is common knowledge that the Blyth-Cadell System was shot out illegally in 1972 (apparently a thorough job was done by white hunters), and hence one would expect the remaining large animals to still be very wary in 1974. Thus it is likely that the six large animals sighted were not a fair indication of the number of large animals remaining on the two rivers in 1974. There could have been substantially more large animals (see Monograph 1, p. 339) in the System, but they were too wary to be sighted.

Thus the results in Table 2 and 3 do not provide evidence for an increasing population on the Blyth-Cadell System; instead they indicate a static or decreasing one, however with the population structure changing. During the November 1975 survey, the ratio of small to large crocodiles sighted was 20.6; on the September 1976 survey it was 9.2 (Table 2). For the two 1981 surveys, this ratio was only 6.8 and 5.2, and for the June 1982 survey it was down to 3.1. It is to be noted that the ratio sometimes varies considerably from survey to survey during the course of a single year; however, the long term trend on the Blyth-Cadell System is downward.

Unfortunately on the Liverpool-Tomkinson System the first reliable survey of the waterway was not made until 1976, so we are unable to compare data with other waterways, especially with the Blyth-Cadell System for 1975. A survey of the Liverpool-Tomkinson System was made in 1975 under the guidance of an assistant (no longer with the research program) to one of the authors (H.M.); however on that occasion, as on many others during 1975, youthful confidence unbacked by sufficient knowledge led to the accumulation of much worthless data--at enormous cost both financially and scientifically. On the July 1976 survey, 180

small and 49 large crocodiles were sighted (Table 2) yielding a (small/large) ratio of 3.7, which is to be compared with ratios of 9.2 and 14.4 for the two 1976 surveys of the Blyth-Cadell System. On the June 1982 survey, 207 small and 67 large crocodiles were sighted yielding a ratio of 3.1, which surprisingly is the same as that obtained for the Blyth-Cadell System. As shown in Table 2, there has been variation among surveys in the ratio of small to large crocodiles sighted, but these variations have not been nearly as large as those found for the Blyth-Cadell System. The increase in the number of large animals sighted on the Liverpool-Tomkinson System has been much less than on the Blyth-Cadell System.

It is known that the Liverpool-Tomkinson System was not as thoroughly shot out as the Blyth-Cadell System (personal communication to H.M. by the then two main aboriginal crocodile hunters at Maningrida, Silas Roberts and Billie Yirrinyin, both of whom worked on H.M.'s crocodile research project during the early 1970's), and that a substantial number of large animals remained on the system when serious hunting of C. porosus ceased at Maningrida in the late 1960's. That large numbers of large crocodiles were shot on the Liverpool-Tomkinson cannot be doubted, for one of the authors (H.M.) recalls seeing in 1972 pathways in Maningrida outlined by large C. porosus skulls. During the course of writing the present paper, the authors had the fortunate opportunity of a discussion with Colonel (Retired) Syd Kyle-Little, who was a Native Affairs Patrol Officer in the Maningrida area from 1946 to 1950 (he was revisiting this area in June 1982, after some 30 years), and who initiated a trial aboriginal project there for the shooting of C. porosus for skins. As a patrol officer he kept a daily diary in which he entered many casual observations of C. porosus. From his observations he had concluded that the Blyth-Cadell System not only contained the largest crocodiles but also contained considerably more than the Liverpool-Tomkinson System. The smallest crocodiles they shot for skins were 3 m in length and the average was 4.5 m. The largest crocodile shot and measured with a tape measure was 6.6 m; this animal was shot on the bank near the mouth of the small creek at km 48.7 on the Blyth River. According to Kyle-Little, large crocodiles were very numerous, and he and two aboriginal helpers shot, on the Liverpool-Tomkinson System, 17 animals on the first night; all animals were ≥4 m in length. Every crocodile shot (some 150) had the stomach contents looked at, and on five or six occasions portions of smaller crocodiles were observed in the contents. He spent much time camped near various freshwater billabongs in the area and states that he never saw many C. porosus in these--usually two or three. He believes that the small numbers are determined by the very limited food supply available in the billabongs.

We have already referred to the surprisingly long period of time that it has taken the C. porosus population to even show signs of a sustained increase. Why is this so? Tables 1 to 5 show that year after year there is recruitment of hatchlings into the systems--at various levels, sometimes high and sometimes low. We know that some 50 percent of these

Table 5. Number of *C. porosus* sighted within the hatchling, small and large size classes on the three major components of the Liverpool-Tomkinson Rivers System: Liverpool mainstream, Liverpool sidecreeks, and Tomkinson (normally 57.0, 27.4, and 56.7 km respectively, but distances can vary from year to year--see page 16, Monograph 7; note especially that during the 1976 Tomkinson survey, the river was surveyed to km 80.1 and that some 11 small and 7 large crocodiles were spotted between km 75-80; normally the Tomkinson is surveyed to km 73.7).

	Liverpool Mainstream			Sidecreeks			Tomkinson			Totals		
	H	S	L	H	S	L	H	S	L	H	S	L
18 July 76	11	64	14	4	27	7	4	89	28	19	180	49
25 May 77	13	67	12	4	28	7	23	71	20	40	166	39
27 October 77	23	77	13*	5	20	4*	28	49	9	56	147	25
27 September 78	13	69	21	7	20	5	17	67	14	37	156	40
NO FLOODING												
16 July 79	24	63	29	5	24	21	260	65	24	289	152	74
19 October 79	17	63	32	2	21	5	142	52	21	161	136	58
15 October 80	28	61	25	17	25	7	26	87	19	71	173	51
HEAVY FLOODING												
2 July 81	8	75	23	1	23	8	17	77	24	26	176	54
5 October 81	2	74	19	2	26	9	30	66	26	34	166	54

Table 5. (continued)

	Liverpool Mainstream			Sidecreeks			Tomkinson			Totals		
	H	S	L	H	S	L	H	S	L	H	S	L
DRY WET--MINOR FLOODING ONLY												
12 June 82	7	66	30	8	36	10	178	105	27	193	207	67
16 October 82	6	82	27	3	32	18	135	56	258	144	171	69

*Bias to large

survive from June of one year to June of the next (Monograph 1, Chapter 8) and enter the 2-3' size class; yet there appears to be little or no increase (and in the case of the Blyth-Cadell a decrease) in the number of non-hatchling crocodiles sighted on the tidal waterway. What is happening? Let us examine the matter more closely.

Consider the Blyth-Cadell System (Table 2). Note that during the October 1974 survey (or alternatively one may use the November 1975 survey; the end result will be essentially the same) 292 small and 6 large crocodiles were sighted. By the time of the June 1982 survey every one of these 292 small crocodiles would, if they survived, be in the large size class, yet in June 1982 only 67 large crocodiles were sighted, or 61 more than in 1974. Thus the minimum loss of sub-adults is (292-61)/292 = 79%. This figure is probably an underestimate because of the wariness in 1974 of the large C. porosus remaining in the Blyth-Cadell System (referred to previously). On the Liverpool-Tomkinson System the situation is much the same; the 180 small crocodiles sighted during the July 1976 survey could all be expected to be in the large size class by June 1982. There were 49 large crocodiles sighted on this first survey and only 67 on the June 1982 survey, giving a loss of (180-18)/180 = 90%.

An alternative way of viewing the matter is given on page 336 of Monograph 1. Consider the number of hatchlings sighted on the latest survey of each year on the Blyth-Cadell System between 1974 and 1981. Hatchling recruitment has been (89 + 50 + 61 + 112 + 155 + 123 + 119 + 72) = 781. From our captive-mark-recapture study (Monograph 1, Chapter 8), it is known that the loss of hatchlings between September and the following June is some 30 percent and from June to the following June it is some 50 percent. Using these estimates, then some 501 of the 781 hatchlings could be expected to have entered the 2-3' and non-hatchling class. The number of non-hatchlings sighted in the October 1974 survey (Table 3) was 298, and in the June 1982 survey it was 272, that is (501 + 26) = 527 non-hatchlings appear to be missing. Not only have the 501 animals recruited in the intervening 1974-1982 period disappeared but some 26 of the original 298 animals are missing also. For the Liverpool-Tomkinson System the recruitment of hatchlings between July 1976 and October 1981 was at least (19 + 56 + 37 + 161 + 71 + 34) = 378, and using the same loss estimates as for the Blyth-Cadell System, one finds that some 249 hatchlings should have entered the non-hatchling class. There were 229 non-hatchlings sighted on the waterway during the July 1976 survey and 274 on the June 1982 one, yielding an increase of 45. Thus one may reason that the 249 non-hatchlings recruited into the waterway, in the period 1976-1982, gave rise to 45 additional non-hatchlings only, and that there has been a loss of some 82 percent of the non-hatchling class. No matter which way one views the matter, it is evident that there are very high and continuing losses of non-hatchlings, and that these losses occur predominantly in the small (2-6') size class. There appear to be some (527 + 204) = 731 non-hatchling crocodiles missing from the sections normally surveyed on the

Blyth-Cadell and Liverpool-Tomkinson Systems alone for the period concerned. Thus the fact that there is little evidence for a major increase in the number of non-hatchling C. porosus sighted is not surprising.

But what has or is happening to the missing non-hatchling crocodiles? This appears to be an exceedingly difficult question to answer and we have been pondering on it over the past three years as we continue to survey and gather more data. We are still almost as mystified about the matter now as we were in 1979 (see pages 14, 15 and 440 to 446, Monograph 1), however certain aspects of the problem are becoming defined more sharply. Study of Table 2 reveals that a small fraction (some 15 to 20 percent) of the 731 missing crocodiles cannot be classified as missing - presumed dead. We shall now discuss these.

On some surveys and in some years, the number of small and/or large crocodiles sighted shows a major increase over the immediately previous survey. It appears that when there is such an increase; it occurs around the June-September period; this was the case on the Blyth-Cadell System in June 1979, when our surveys revealed a major influx of both small (from 221 to 287, significant at the 99 percent level) and large animals (from 23 to 55). On the Liverpool-Tomkinson System, the July 1979 survey showed a major increase in the number of large animals sighted (from 40 to 74) but no increase for small animals. In fact, as discussed in Monograph 1, pages 441 to 445, it appears that a major increase in the number of large C. porosus sighted was a general phenomenon on the tidal waterways of the northern Australian coastline during the June-August 1979 surveys, with the exception of Arnhem Bay (Monograph 11).

We suggested that the common factor, which may have been connected with this general influx of animals, was the exceedingly dry wet season of 1978-1979 and the severe drought conditions which prevailed until the wet season of 1979-1980. Such conditions might be expected to force any itinerant animals in swamp areas and semipermanent waterholes back into the tidal waterways. However, we pointed out that there are a number of worrisome points about this; firstly, there are very few swamp areas in the vicinity of the Blyth-Cadell System (certainly not enough to hold the number of animals involved), and secondly, if the sub-adults were returning from non-TYPE 1 tidal waterways elsewhere (for instance the Milingimbi Complex, see Monograph 9), then why would a very dry wet season and severe drought conditions trigger the return of sub-adults to TYPE 1 systems from non-TYPE 1 systems. In addition there were indications of an increase, rather than a decrease, in the number of non-hatchlings sighted in TYPE 3 systems in August 1979 (see the results for Majarie and Wurugoij Creeks, Table 1). Finally, how does one account for the decrease in the number of large crocodiles (from 74 to 58) spotted on the Liverpool-Tomkinson System during the October 1979 survey (Table 2); where did they disappear to? The missing crocodiles could not have returned to the freshwater swamps and/or billabongs from which it was postulated they had come, for these were even drier in October than in June and July. One is thus tempted to dismiss the "drying up swamp and billabong" explanation for 1979. However, the 1981-1982 wet season along the northern Arnhem Land coastline was again a dry one, and again there has been an influx of large animals into the Goomadeer (from 3 to 14), Blyth-Cadell (from 39 to 67), and Liverpool-Tomkinson (from 54 to 67) Systems (see the results for the June 1982 surveys in Tables 1 and 2). The increase in the number of large animals sighted on the Liverpool-Tomkinson System was accompanied by a major increase of small animals (from 166 to 207, significant at the 95 percent level), whereas this was not so for the Blyth-Cadell and Goomadeer Systems. In June 1979 the increase in the number of large animals sighted (from 23 to 55) on the Blyth-Cadell System was accompanied by a significant increase at the 95 percent level (from 221 to 287) in the number of small animals sighted. However, on the Liverpool-Tomkinson System this was not so.

Thus we ask what role, if any, do the dry wet seasons play in determining the influx of small and especially large C. porosus onto the main sections of the tidal waterways?

It is to be noted from Table 2 that on the second survey of the Liverpool-Tomkinson System in 1979, namely the October survey, the number of large animals spotted had decreased (from 74 to 58), but still was at a considerably higher level than for the September 1978 survey when only 40 large animals were spotted. The number of small animals sighted had also decreased, but not significantly, from 152 to 136. For the Blyth-Cadell System there was a similar occurrence; however, the next survey, after the June 1979 one, could not be made until October 1980; the drop in the number of small animals was from 287 to 249, just missing being significant at the 95 percent level.

Our results thus suggest that as the number of large animals increases on a TYPE 1 tidal waterway, the number of small crocodiles usually decreases or increases marginally only. Furthermore the results suggest that the disappearance or main ejection of small crocodiles from TYPE 1 waterways may occur around the October period, the breeding season, and they provide support for the model we proposed for the dynamics of C. porosus populations.

Note again the results for the number of small and large animals sighted on the Blyth-Cadell and Liverpool-Tomkinson Systems since 1979. On the basis of those results one might guess that the number of small crocodiles which will be sighted on the October 1982 survey of the Liverpool-Tomkinson System will be less than on the June 1982 survey. One might also expect to see a small decrease on both the Blyth-Cadell and Liverpool-Tomkinson Systems in the number of large crocodiles sighted; for it could be expected that a number of the large animals which entered the systems between the 1981 and 1982 surveys would still not be sexually mature (or just) and hence might be excluded by the breeding adults. The October 1982 survey may well provide some interesting results.

It is of interest to note that the number of both small and large animals sighted on the Blyth-Cadell and Liverpool-Tomkinson Systems during the June 1982 surveys are almost identical (Table 2), though the situation was much different when our surveys first started in the mid 1970s. The major increase in the number of small crocodiles sighted on the Liverpool-Tomkinson during the June 1982 survey is probably the result of the large hatchling recruitment on the Tomkinson River over the 1978-1979 wet season (Table 5). But where were these small animals in the intervening period; where did they come back from? The same question applies to the influx of large crocodiles on both the Liverpool-Tomkinson and Blyth-Cadell Systems. In an attempt to throw some light on these questions we must consider the two waterways in more detail.

The Liverpool-Tomkinson System is in many ways similar to the Blyth-Cadell System and at first sight the two TYPE 1 systems appear to parallel one another to a large degree (Monographs 1, 7, and 15). The Liverpool-Tomkinson System lies some 30 km to the west of the Blyth-Cadell System. The Blyth River has a major tributary, the Cadell River (TYPE 1), which joins it at km 19.1. The Liverpool River also has a major tributary, the Tomkinson River (TYPE 1), which joins it at km 17.0. The maximum navigable (by 4 m survey boat) length of the Liverpool mainstream is 66.3 km (normally can be surveyed to km 60 only), whereas for the Blyth mainstream it is 59 km (normally can be surveyed to km 49.8 only). Both mainstreams have large upstream drainages. If one compares low tide salinities towards the end of the dry season at corresponding distances on the Liverpool and Tomkinson Rivers, one finds that the Liverpool salinity is lower than that for the Tomkinson by a factor of 3 or so (Monograph 7). Looking at the Blyth and Cadell Rivers, the Blyth has salinities several times lower than the Cadell (Monograph 1, Chapter 3). Thus in the two systems, from the point of view of salinities, the Liverpool parallels the Blyth, and the Cadell parallels the Tomkinson. In its upstream reaches, past km 50, the Blyth River shows typical freshwater habitat; past km 56 the river is very rocky and after km 59.8 it breaks up into a series of freshwater waterholes. Correspondingly, the Liverpool River becomes sandy past km 60 and is joined by the Mann River at km 68. Both streams break up into a number of rivulets and numerous semipermanent and permanent freshwater waterholes in stony country. On the Liverpool, sporadic C. porosus might get upstream of the Mann Junction. Typically, the number of C. porosus sighted on the upper navigable freshwater sections of both of the mainstreams falls off rapidly (Monograph 1, Chapters 6, 9, and Addendum; also Monographs 7 and 12).

The maximum navigable length of the Cadell River is some 30 km (from km 19.1 to 48.8); this is followed by some 4.5 km of shallow, narrow, giant log strewn waterway, running through dense jungle. There is a narrower sidecreek running off from the mainstream at km 48.8, and this runs through similar jungle for some 2 km until it peters out in waterholes. As viewed from a helicopter, the habitat looks as if it might be suitable as a refuge for some sub-adults, but the amount of sunlight getting through the dense jungle canopy would be limited on many sections. The river finally breaks up into a series of small semipermanent and some eight larger permanent freshwater waterholes. It is to be noted that the dry season food supply for C. porosus in these would be fairly limited, as the supply is only effectively replenished during some of the wet seasons.

The Tomkinson River, on the other hand, has a much longer navigable length of some 64 km (from km 17 to 81.3, but normally can be surveyed to km 73.7 only), beyond which it shallows out over a distance of several km into a semipermanent paperbark swamp which can be dry or wet during a given dry season, depending upon how wet the previous wet season was. Upstream of km 70 the banks become lined increasingly with Melaleuca and though the stream is narrow (some 6 to 8 m), the mud banks are usually gently sloping. The terminal section of the river upstream of km 70, though providing excellent C. porosus habitat, floods almost every year. Both the Cadell and Tomkinson Rivers are still tidal at their endpoints for navigation.

The nature and extent of the sidecreeks varies considerably between the Blyth-Cadell and Liverpool-Tomkinson Systems. On the Blyth-Cadell System there is only one major sidecreek, namely Creek B at km 3.5, which has a navigable section of 4.1 km; Creeks A, C, D, F, and G have a total navigable length of some 8 km only. These minor creeks, which are on the downstream km 0-15 section of the Blyth River, usually become hypersaline towards the end of the dry season and are TYPE 2-3. On the Liverpool-Tomkinson System there are a number of more substantial creeks:

	Type	Navigable length (km)
Gudjerama Creek at km 5.5	3	5.8
Morngarrie Creek at km 14.4	3	2.9
Mungardobolo Creek at km 17.0	3	8.7
Maragulidban Creek at km 30.0	1	7.8
Atlas Creek at km 58.4	1	1 to 2.8

Mungardobolo Creek is one of the most hypersaline creeks in northern Australia, and we discussed previously at some length (Monograph 7, also Monograph 1, Chapter 7) the matter of the itinerant C. porosus sighted in it. Essentially, it appears to be a small TYPE 3 rearing stockyard for sub-adults, large and small, excluded from elsewhere on the Liverpool-Tomkinson System.

On the other hand, Maragulidban Creek is a relatively short TYPE 1 system, joining the Liverpool mainstream at km 30. It becomes quite narrow with steep cut-away banks and is quite log-strewn upstream of our normal terminal survey point at km 37.8, but not as log-strewn as the unnavigable end section of the Cadell River. Beyond km 37.8, the stream winds a further torturous course for some 7 km through relatively thick jungle and then breaks up into a series of semipermanent and permanent

freshwater waterholes, which are not as large as those on the Cadell River. At approximately km 44, there is a sidecreek which runs for some 2 km through exceedingly dense jungle, finally breaking out into a shallow semipermanent paperbark swamp. The upstream sections of both the Cadell River and Maragulidban Creek are quite similar and undoubtedly could provide a refuge for some sub-adults--probably mostly in the large size class--excluded from other sections of the systems.

We now examine the number of C. porosus sighted during the various surveys on the component parts of each system with a view to trying to track down where the increases and decreases occur. Tables 4 and 5 contain the relevant data.

Consider the small crocodiles sighted on the Blyth-Cadell System during the 1975 and 1976 surveys. It will be noted that the number of small crocodiles sighted on the system dropped significantly at the 95 percent level, from 289 to 240, between the November 1975 and September 1976 surveys; this decrease occurred mainly on the Cadell River, though there was a decrease of 18 small animals sighted on the Blyth mainstream also. The major flooding that occurred over the 1975-1976 wet season was of historic dimensions, and this may well have been connected with the decrease in the number of small animals sighted (Monograph 1, p. 335). However, the decrease in small animals was associated with an increase from 14 to 26 in the number of large animals sighted. This increase was mainly on the Cadell River and this too might have been responsible for the decrease in small animals. We are unable to say where the small animals disappeared to or what happened to them.

The number of both small and large animals sighted then fluctuated within surprisingly narrow limits until the June 1979 survey. During this survey, on the Blyth mainstream, the number of large animals sighted increased dramatically from 15 to 40 and from 23 to 55 for the overall Blyth-Cadell System. For us it was exciting to see so many large animals; they were mostly concentrated at the mouth region of the Blyth River and on the sidecreeks of the downstream section of the river. Where had these animals come from, and were they coming into the river or leaving it? Since they were not sighted during the September 1978 survey, the evidence points to these animals trying to gain entrance to the waterway. The number of small crocodiles sighted also increased significantly at the 95 percent level, from 221 to 287; there being an increase of 41 small animals on the Blyth mainstream between km 15 and 35; 27 of these were in the 2-3' size class and these were mostly sighted on the km 20-30 section. Ten of the remaining 14 animals in the 3-6' size class were sighted on the km 0-20 mouth section. There was also an increase of 27 small animals on the Cadell River of which 6 were in the 2-3' size class and 21 in the 3-6' size class; 15 of the latter were in the 3-4' size class. The distribution of the crocodiles along the Cadell River suggests that most of the 3-6' animals may have come downstream from the inaccessible extreme upstream section of the waterway. Note that there had been no increase in the number of large animals sighted on the Cadell River on the June 1979 survey.

On the October 1980 survey of the Blyth-Cadell System, the number of non-hatchling crocodiles sighted had decreased from the June 1979 level, from 342 to 281; significant at the 95 percent level. This decrease consisted of a drop of 38 small animals and 23 large ones. As shown in Table 4, it appears that the loss of both small and large animals was largely from the Blyth mainstream (32 and 18 respectively); five large animals were also missing from the sidecreeks. Again we are unable to say what happened to these animals. There was little change on the Cadell River.

The survey of July 1981 revealed a situation much like that of the October 1980 survey, with only minor changes in the number of large and small crocodiles sighted on the Blyth-Cadell System. However, the October 1981 survey revealed a further major decrease, from 253 to 204, significant at the 95 percent level, in the number of small animals sighted. Note that the number had by then gone down from 292 in 1974 to 204. The losses occurred on all three major components of the Blyth-Cadell System. On the Blyth mainstream, the losses occurred on the downstream and extreme upstream sections; on the Cadell the losses were on the downstream sections. Interestingly, there was an increase of small animals on the upstream end sections of the Cadell, suggesting that some of the missing animals may have moved into the inaccessible region of the Cadell discussed previously. The loss of small animals from the mouth region of the Blyth suggests that the animals may have left the waterway, if they are alive at all. The number of large crocodiles remained essentially the same.

The survey of the Blyth-Cadell System in July 1982 showed essentially no increase in the number of small animals sighted (there was a loss of 35 [2-3'] but a gain of 36 [3-6'] animals, mostly in the 4-6' range); a decrease of 9 animals on the Blyth mainstream was counterbalanced by an increase of 9 on the Cadell. However, the distributional pattern of the small animals along the Blyth mainstream and the Cadell had changed since the October 1981 survey. Whereas on the October 1981 survey some 30 small animals were sighted on the km 0-20 section of the Blyth mainstream, on the June 1982 survey, 54 small animals were sighted on the same section. On the other hand, the number of animals on the km 25-40 section had decreased from 69 to 30. These results suggest that the small animals downstream may have been in the process of being excluded from the waterway by large crocodiles (or since many were in the 4-6' range, they may have been entering it?). This possibility is supported by the fact that there was an increase from 39 large animals sighted on the system during the October 1981 survey to 67 during the June 1982 one; 17 of the increase of 28 were sighted on the km 0-15 section of the Blyth mainstream and its sidecreeks, thus suggesting strongly that these large crocodiles had entered the Blyth through its mouth. A total of 31 large C. porosus were sighted on the km 0-15 mouth section and sidecreeks; exactly the same number were sighted on this section during the June 1979 survey. However, whereas there was no increase in large animals sighted on the Cadell during the June 1979 survey (the number fluctuated between 0 in 1974 to 9 in October 1981), the June 1982 survey shows 20 large animals in the Cadell--an increase of 11, and all this increase occurred on the mouth sections of the Cadell. Since the Cadell joins the Blyth River at km 19.1 and since there was no increase at all in the number of large animals sighted upstream on the Cadell, it appears that the 11 new animals also entered the Blyth-Cadell System through the Blyth River mouth. The increase of 9 small animals sighted on the Cadell is interesting, for their distribution along the river is such as to suggest exclusion from the Blyth mainstream. The October 1982 survey of the Blyth-Cadell System may well reveal considerable readjustment between the increased number of small and large animals sighted on the mouth sections of both the Blyth and Cadell Rivers and show not only a small decrease (mentioned earlier) in the number of large animals sighted on the overall Blyth-Cadell System but perhaps a further decrease in the number of small animals sighted as well. However, it is difficult to believe that the number of small C. porosus could decrease much further on the system, and it appears that a stage is being reached where the number of small animals sighted will commence increasing, but with the number of large animals increasing faster, thus yielding a decreasing, but fairly fluctuating ratio of small to large C. porosus.

As is evident from our discussion, consideration of the survey results for the Blyth-Cadell System can be indicative only as to where the fluctuating numbers of small and large crocodiles disappear to and return from. Most of these large C. porosus are in the 6-8' size class and thus are sexually immature or just sexually mature animals, for it is known that females are often sexually mature when they reach the 6-7' size class (see Monograph 1, p. 339, also personal communication from Dr. Gordon Grigg). The evidence suggests strongly that most of these large crocodiles and a substantial fraction of the excluded small crocodiles leave and re-enter the Blyth-Cadell System through the mouth of the Blyth River. Those that leave go out to sea and are probably lost, or they travel along the coastline until they reach another tidal waterway to which they gain entrance.

To the east of the Blyth River mouth, the closest tidal waterways are those discussed in Monograph 9: Ngandadauda, Bennett, Darbitla, Djigagila and Djabura Creeks, all TYPE 3 or 2-3 waterways, and which provide excellent rearing stockyards for sub-adult and just mature C. porosus, referred to in our model. However to reach the first of these waterways, Ngandadauda Creek, necessitates a sea journey of some 36 km and the rounding of Cape Stewart. This creek is also joined to Creek B on the Blyth River by an open paperbark swamp, and crocodiles could move from one to the other during the height of the wet season (see Monograph 9, p. 39). There is a very small but distinct channel joining the two creeks.

When last surveyed in June 1979, 39 large and 44 (3-6') animals were sighted in the creeks above, and since they are all TYPE 3 or 2-3 waterways, nearly all the animals sighted must have been derived from elsewhere. The Blyth-Cadell System is probably one of the sources for these crocodiles.

Between the Blyth River mouth and the Liverpool River (to the west) there are four small TYPE 3 coastal creeks, each having extensive sand bars at the mouth and which may be entered only from the sea with great difficulty, even at high tide. The first two of these, Beach (local name) and Anamayirra Creeks, are some 10 km from the Blyth River mouth. Crab Creek (local name) and another unnamed creek, so small as to be of no consequence, are a farther 13 km to the west. We were able to gain entrance by land and to survey Crab Creek in October 1981 for the first time and sighted two large animals in it. For the June 1982 survey, a helicopter was chartered from Darwin (some 320 km from Maningrida) so that access could be gained to Anamayirra and Beach Creeks and two large waterholes on the Cadell River, and to check various other regions hitherto inaccessible to us. On the spotlight survey of Beach and Anamayirra Creeks, 13 small and 9 large animals were sighted, thus revealing two further good rearing stockyards for crocodiles excluded from TYPE 1 systems nearby, such as the Blyth-Cadell and Liverpool-Tomkinson. Both Anamayirra and Beach Creeks drain paperbark swamps, and Anamayirra Creek then breaks into a number of waterholes, containing sporadic C. porosus--we caught one of these in 1976. Our June 1982 survey of these waterholes revealed no crocodiles.

The only other areas to which crocodiles, excluded from the sections of the waterway normally surveyed, could move to or come from in the vicinity of the Blyth-Cadell System are the Cadell River waterholes and the extreme upstream sections of the Blyth and Cadell River mainstreams.

As reported on page 446 of Monograph 1, in October 1980 we surveyed the extreme upstream freshwater sections of the Blyth River from our normal terminal point at km 49.8 to km 59 and the two large waterholes extending from km 59.8 to 64.6. We sighted six crocodiles (H, EO>6', 7-8', 2-3' and 6-7' in that order) on the km 49.8-56 section, none on the km 56-59 section, and none in the two large waterholes. We resurveyed the km 49.8-59 portion of the river in July 1982. On this survey, only five crocodiles were sighted, one hatchling and four large, all between km 50.1 and 54.5. Strangely the stream appears to be barren not only of crocodiles but of fish also, upstream of km 55-56.

On the Cadell River, we are unable to survey upstream of km 48.8 because the stream shallows and narrows beyond that point and is strewn by giant logs as it winds a further tortuous 4.5 km through dense jungle --undoubtedly we would sight a number of both small and large crocodiles if we were able to survey it, for the waterholes which the stream drains do contain some small and large C. porosus. There are eight main permanent waterholes at varying distances upstream of km 53.3, with a total length of some 10 km. Using a vehicle or a helicopter to gain

entrance, we were able to survey four of the main waterholes with lengths of 4.0, 2.0, 0.9, and 0.8 km. Our surveys revealed 2 small and 12 large crocodiles, 5 in each of the large waterholes and 2 each in the smaller ones. Thus as suspected, the waterholes do provide limited alternative habitat for a small number of both small and large C. porosus which may be excluded from the river system proper.

Thus one is led to the conclusion that there is sufficient alternative habitat for that relatively small percentage (15-20%) of both small and large crocodiles which leave and later re-enter the TYPE 1 Blyth-Cadell System and that such crocodiles are sighted in these. However, we are unable to provide direct proof with specific animals; this can only be done using capture-mark-recapture methods or radio telemetry. However, there are a number of major difficulties related to the use of either method. The capture and handling of an animal may well be the cause of it leaving the system temporarily (see Monograph 7, pp. 75 and 76, for a case at point)--how is one to know? This matter is particularly relevant for the present study concerning, apparently, excluded and returning animals. In addition there would be the great difficulty and cost of endeavoring to capture a very large fraction of the sub-adults inhabiting a waterway, for one would have to use passive techniques to minimize the problem referred to above. Some 15 to 20 percent of the sub-adults appear to remain on a TYPE 1 waterway, another 15 to 20 percent appear to fluctuate in and out of the waterway (or proceed to the more inaccessible and normally unsurveyable sections), with the remainder entering the missing, presumed dead class; for a meaningful study, it would be necessary to work with a very large fraction of the animals in a system. There is also the technical difficulty of running a microprocessor based telemetry system (which would have to be used) in a remote area such as Maningrida. Finally, there is the major stumbling block of scientific permits; these are required by law before a crocodile may be captured. The Northern Territory Government demonstrated recently how dangerous and costly it can be to try to carry out a research program requiring scientific permits, when it launched a prosecution against one of the authors (H.M.) who was holding two, supposedly valid, permits. This not only wrecked some very important scientific work (see Monograph 1, pp. 387 and 438) but also effectively ensured that we do not proceed with radio telemetry studies of C. porosus. The risk of further prosecution appears to be far too great. We need to use an alternative method and have some ideas on this matter.

We now turn to the some 527 small crocodiles in the missing, presumed dead class on the Blyth-Cadell System. What has happened to them? We have direct evidence that over the past year at least three large animals were drowned in barramundi fishermen's nets set outside and inside the mouth of the Blyth River, where, as discussed previously, the density of animals appearing to leave or enter the river is greatest. As to the remainder, we are simply unable to say, and radio telemetry or capture-mark-recapture methods are unlikely to provide the answer, for once an animal is dead, these methods are unlikely to be of value. It is known that large C. porosus sometimes kill smaller C. porosus, and it is known that they sometimes eat smaller C. porosus (see Monograph 1, pp. 33 and 334). It is known that large sharks take crocodiles also, for recently a 16 foot white pointer was caught in Moreton Bay, Queensland, with a 4-5' C. johnstoni in its stomach, and our own studies have documented many cases of C. porosus being bitten by sharks which are very prevalent in the tidal waterways of northern Australia, especially in the mouth sections. However, hitherto we believed these were isolated cases. Now we wonder about it and are becoming more convinced that mature adult C. porosus and sharks may account for the high fraction of missing, presumed dead C. porosus.

Just as for the Blyth-Cadell System, we can give also, a detailed analysis of the number of C. porosus sighted on the three major components of the Liverpool-Tomkinson System (Table 5). The analysis runs along the same lines but there are important differences between the two systems. Note the essential constancy of the number of small crocodiles sighted on the Liverpool mainstream during the surveys between 1976 and 1982. There is some indication of perhaps a minor drop in the number of small crocodiles sighted as the number of large animals increased. Note too the exceedingly small recruitment of hatchlings on the Liverpool mainstream, which of course could partly account for the fact that there has been only minor variations in the number of small animals sighted.

The small recruitment of hatchlings is difficult to understand for there are numerous nesting sites on the mainstream (see Monograph 7, p. 34). For our capturing program in 1973, 1974, and 1975 we know that there were at least 62, 34, and 60 hatchlings respectively on the Liverpool mainstream in those years. The figure of 11 hatchlings during the November 1976 survey is understandable, for the wet season of 1975-1976 was of historic dimensions and the Liverpool System was flooded accordingly. No nests could have survived the exceedingly high flood levels and the few hatchlings sighted in 1976 probably came from one or more swamp nests. Since 1976, the maximum number of hatchlings sighted has been 28. This simply does not correspond with the excellent nesting habitat on the Liverpool mainstream or with the number of large animals sighted on it.

It will be noted that there was only minor recruitment of hatchlings on the sidecreeks on the river system, but in 1979 and again in 1982 there was, relatively speaking, very heavy recruitment of hatchlings on the Tomkinson River. The Tomkinson also has some excellent nesting habitat and almost the same number of large animals are sighted on it during surveys as on the Liverpool mainstream. Did Magnusson's disturbance of nesting and large animals during the course of his Ph.D. nesting studies between 1975 and 1977 on the Liverpool-Tomkinson have something to do with the matter? It seems farfetched, but we know of no other relevant factor. The matter of breeding and nesting on the Liverpool-Tomkinson obviously requires more detailed study.

The increase in the number of large animals sighted during the 1979 surveys of the Liverpool mainstream occurred mostly downstream of the mouth of Maragulidban Creek which joins the Liverpool mainstream at km 30. The decreases which followed in 1980 and 1981, also occurred on the same sections. There was an increase of 11 large animals sighted on the June 1982 survey of the mainstream, and 8 of these were again centered on these sections; the remaining three were sighted on the km 3-10 mainstream mouth section, indicating their arrival via the river mouth.

One should now note the major increase from 5 large animals sighted on the sidecreeks during the September 1978 survey to 21 on the July 1979 survey and then the drop back to 5 for the October 1979 survey. The increases and decreases took place largely on Maragulidban and Mungardobolo Creeks. The results suggest strongly that Maragulidban Creek is acting as a major channel for the entry and departure of large animals--but not for small crocodiles. To check this matter further, it was decided to use a small dinghy rather than our normal survey boat, and to survey upstream as far as possible beyond our normal terminal point at km 37.8. We were able to survey to km 42.5 which is some 2.6 km before the stream breaks up. Only one large crocodile was sighted, in the EO>6' class, and no small crocodiles were seen. Thus our suggestion that Maragulidban Creek acts as a channel, between the paperbark swamp and waterholes, which start at km 49.8, for the entry and departure of large but not small C. porosus gains support.

On the Tomkinson River (Table 5) the number of large animals sighted during surveys has varied from 28 in July 1976 to 9 in October 1977, gradually rising to 27 in June 1982. The decrease from the 20 large animals sighted in the May 1977 survey to 9 sighted on the October 1977 survey was spread fairly evenly over all sections of the river surveyed normally. Those animals lost from the mouth section of the Tomkinson may have left the Liverpool-Tomkinson System. However, it is more likely that these, as with the other large animals (probably sexually immature sub-adults or just mature adults) missing from the upstream sections of the river, were forced by the breeding adults of October 1977 even further upstream onto the terminal sections. On these sections, nesting appears to take place seldomly, and we have been unable to gain entrance to them on most surveys. Support for the view just expressed is provided by the survey of July 1979 when the number of large animals sighted was 24, having increased from 9 in October 1977. The increase occurred predominantly on the upstream sections of the Tomkinson.

Also note the decrease in the number of small animals sighted on the Tomkinson during the October 1979 survey. Though this decrease is not significant statistically, it does point to the small animals being excluded by breeding adults on the Tomkinson where most of the nesting on the Liverpool-Tomkinson System appears to be taking place. The increase from 52 small animals sighted on the October 1979 survey to 87 for the October 1980 survey is accounted for purely by an increase of 36 (2-3') animals arising from the 142 hatchlings sighted during the October 1979 survey. Using results on survivorship for the Blyth-Cadell System (Monograph 1, Table 8.4.1), one would have expected some 50 percent, or 71 of the 142 hatchlings, to be in the 2-3' size class by October 1980. Thus the increase of 36 (2-3') animals appears to be too small by a factor of about 2 and the missing portion must have been either excluded, probably to the upstream terminal sections of the Tomkinson referred to, and/or entered the class missing, presumed dead. The number of small crocodiles sighted on the July and October 1981 surveys then decreased from the 87 of the October 1980 survey to 77 and 66 respectively, but the results of the June 1982 survey show a significant increase at the 95 percent level in the number of small animals sighted on the Tomkinson, the number rising to 105. In addition, on Mungardobolo Creek, there was an increase of six small and two large crocodiles. It should be recalled that the Tomkinson and Mungardobolo both join the Liverpool mainstream at km 17.0. Of the increase of 45 small animals on the Tomkinson and Mungardobolo, 9 were in the 2-3' size class, derived from hatchling recruitment the previous year, 29 were in the 3-5', and 7 in the 5-6' size classes, and hence it appears that the major increase consisted of animals derived from the large hatchling recruitment on the Tomkinson in 1979. The increase in the small size classes was distributed relatively uniformly over the Tomkinson and Mungardobolo, indicating that the animals had come downstream from the normally inaccessible terminal sections of the Tomkinson. By making special efforts during the June 1982 survey, we were able to survey the Tomkinson from our normal terminal point at km 73.7 to km 81.3. We spotted 32 C. porosus as follows: 1 (3-4'), 7 (4-5'), 5 (5-6'), 5 (6-7'), 3 (>7'), and 11 (EO), thus supporting our suggestion that the terminal sections of the Tomkinson are providing rearing stockyards for sub-adults excluded from other sections of the waterway. In the future, we shall make great efforts to survey this section of the waterway during the course of our normal surveys.

From our discussion, it appears that though there are many similarities between the Blyth-Cadell and Liverpool-Tomkinson Systems, there are also a number of important differences. Whereas on the Blyth-Cadell System there are relatively few alternative areas for excluded sub-adults to go to, on the Liverpool-Tomkinson System the opposite appears to be the case. Thus, whereas sub-adult C. porosus on the Blyth-Cadell System appear to be excluded and re-enter largely via the mouth of the Blyth River, on the Liverpool-Tomkinson System there are alternative rearing stockyards within the system, such as the terminal sections of the Tomkinson and Maragulidban or within TYPE 3, Mungardobolo Creek. In view of this one might expect that the percentage of sub-adults classified as missing, presumed dead, on the Liverpool-Tomkinson System would be less than on the Blyth-Cadell System. However as we have seen, the reverse appears to be the case. We had previously suggested in our model that sharks might be the main predator on sub-adult C. porosus. Though not dismissing this suggestion at this stage, our discussion above also suggests that one of the main predators of sub-adult C. porosus may be adult C. porosus.

ACKNOWLEDGEMENTS

The authors wish to thank the Science Foundation for Physics and the University of Sydney for their continued financial support. We also wish to thank the Aboriginal people in the Maningrida area for their help. Dr. Peter (H.P.B.) Harvey and Mr. Colin Wiles (the helicopter pilot) helped to ensure that our June 1982 surveys were amongst the best ever.

APPENDIX ON SURVEY

OF WATERWAYS IN THE MANINGRIDA

MONITORING AREA--OCTOBER-NOVEMBER 1982

LIVERPOOL-TOMKINSON AND SURROUNDING WATERWAYS--SURVEYS OCTOBER 16-NOVEMBER 1, 1982

1. Liverpool Mainstream (Table 5)

There was an increase from 66 small crocodiles sighted during the June 1982 survey to 82 small crocodiles sighted during the October 1982 survey. This increase occurred just upstream and downstream of the mouth of the Tomkinson River, and hence it is likely that it is accounted for by small crocodiles excluded from the Tomkinson River.

A small decrease--from 30 to 26--in the number of large animals sighted on the mainstream could be real or just normal fluctuation in counts; however, the distribution of the large animals sighted varied considerably from that in June 1982. From km 3-30 there were 19 large animals sighted in June 1982, whereas in October 1982 only 14 were seen. As discussed below, a number of large crocodiles probably moved from the Liverpool mainstream into the sidecreeks.

The extreme upstream section of the Liverpool mainstream (km 60-66.4) was surveyed for the first time, and five small and three large *C. porosus* were sighted. This section, which is quite shallow, very sandy, and stump-ridden, provides limited alternative habitat for sub-adults driven from the more desirable sections of the mainstream.

The number of hatchlings sighted on the mainstream remained essentially constant (6 instead of 7).

2. Tomkinson River (Table 5)

As predicted after the June 1982 survey, the number of small crocodiles sighted on the section of the Tomkinson, normally surveyed (km 17.0-73.7) dropped dramatically, from 105 to 56 (∿47%).

There also was a decrease from 18 to 11 in the number of small animals sighted on the extreme section of the Tomkinson (km 73.7-81.3), not included in the normal survey section.

The number of large animals sighted decreased only marginally from 27 to 25 on the km 17-73.7 section, and the number of hatchlings sighted decreased from 178 to 135. However, it should be noted that there was an input of hatchlings from one or more late nests during the intervening period. A late June nest sighted at km 65 in July 1982 (no nests laid down after the end of March had been observed previously) was excavated by October, and some of the hatchlings sighted on the Tomkinson, were very small--obviously coming from successful late nest(s).

The number of large crocodiles sighted between km 73.7-81.3 did not change (13), however their increased number (from 4 to 11) on the km 17-30 mouth section suggests that a number of large animals were being excluded from the upstream breeding sections of the Tomkinson (km 30-73.7) where the number had dropped from 23 to 14.

Comparison of the number of small crocodiles sighted during the June and October surveys on each of the sections of the Tomkinson shows that, with the exception of the km 20-30 section, the losses were fairly uniform throughout the river, including the extreme km 73.7-81.3 section. The missing (105-56) = 49 small crocodiles from the km 17-73.7 section (of which 37 were in the 3-6' size classes) and the missing (18-11) = 7 from the 73.7-81.3 section (all in the 3-6' size classes) must either be "missing, presumed dead" or have been excluded from the surveyable sections of the river; recall the 16 additional small animals sighted on the Liverpool mainstream (actually there was an increase of 19 [3-6'] and a loss of 3 [2-3'] animals), mainly near the mouth of the Tomkinson. Some may have been forced upstream of km 81.3, since 13 crocodiles were sighted on the terminal 1.3 km surveyed from km 80-81.3. However, the Tomkinson becomes very shallow upstream of km 81.3 and soon simply peters out, so the amount of adequate habitat there is limited. Comparison of the June and October histograms for the km 73.7-81.3 section of the river shows the crowding of the crocodiles towards the terminal portion of this section. However, it should be noted that heavy barramundi activity was observed there during the survey of the km 73.7-81.3 section, and hence the crocodiles may have been concentrating there because of the plentiful supply of food.

Exclusion and even killing of the sub-adults by the mature animals, especially during the breeding season, which occurs around the October-November period, appears to be a major factor involved in the decrease and redistribution of sub-adult C. porosus. These factors could be expected to be more important on the Tomkinson than on the Liverpool River, since most of the successful breeding appears now to be taking place on the Tomkinson rather than on the Liverpool River--even though the number of large C. porosus sighted on each is closely the same. Our results bear this out.

During the night-time survey of km 73.7-81.3 on November 1, 1982, a (7-8') freshly dead male C. porosus was found floating in the water at km 73. It appeared to be in excellent condition and had blood coming from its nostrils--it was probably killed by a blow from a larger crocodile.

3. Sidecreeks of the Liverpoor River (Table 5)

A minor decrease in the number of small animals sighted, from 36 to 32, is essentially accounted for by the decrease from 17 to 12 in the number sighted on Mungardobolo Creek; there were minor variations of one to two small crocodiles on the other sidecreeks.

The most noteworthy change occurred in the number of large animals sighted, the number increasing from 10 in June to 18 in October, with 5 of the increase occurring on Gudjerama Creek (from 1 to 6); 1 on Mungardobolo (3 to 4), and 2 on Maragulidban Creek (5 to 7). These animals probably include the six large animals not sighted on the Liverpool-Tomkinson mainstreams. Both Mungardobolo and Gudjerama Creeks are TYPE 3 and hence do provide temporary alternative habitat for the excluded large crocodiles.

4. Overall Liverpool-Tomkinson Rivers System (Tables 1, 2, 3 and 5)

Table 5 shows the overall results for the various detailed changes between the June and October 1982 surveys, discussed above--a decrease of 49 hatchlings (193 to 144), a decrease of 36 small crocodiles (207 to 171) of which 23 were in the 3-6' size classes, and an increase of two large C. porosus (67 to 69). A portion of the 13 (2-3') animals can probably safely be assumed to be in the class missing, presumed dead; however, some of the remaining 23 (3-6') missing animals could even be among the additional 10 (3-6') animals sighted on the waterways of Rolling and Junction Bays (Table 1, 2, 6, and 7).

These changes are in keeping with the predictions made by our model for the dynamics of a population of C. porosus and provide further support for its basic correctness. A minor variation occurred in relation to the number of large animals sighted; rather than decreasing slightly as predicted, there was an increase of two. This variation is partially accounted for by the three additional large animals sighted on Mungardobolo and Maragulidban Creeks and by the five large animals entering TYPE 3 Gudjerama Creek near the mouth of the Liverpool rather than leaving the river system. They might well be excluded later in the breeding season.

The results shown for the number of non-hatchling C. porosus sighted on the Liverpool-Tomkinson Rivers System during surveys from 1976 to 1982 provide some evidence for the commencement of a slow recovery in the C. porosus population on this waterway. Though the number of non-hatchlings sighted dropped from 274 for the June 1982 to 240 for the October 1982 survey, this latter number is still greater than that for any previous year's survey. When this fact is combined with the sighting of 144 hatchlings during the October 1982 survey, then it is likely that the non-hatchling numbers will continue to rise, albeit slowly, with a generally decreasing small/large ratio. Fairly wide fluctuations, however, may be expected.

THE TIDAL WATERWAYS OF ROLLING AND JUNCTION BAYS, OCTOBER 11-14, 1982

Table 6 summarizes data shown in Table 1, which were obtained during surveys of the tidal waterways of Rolling and Junction Bays from 1975 to 1982.

Table 6. Number of C. porosus sighted within the hatchling, small and large size classes on the tidal waterways of Junction and Rolling Bay, which are within the Maningrida monitoring area. *Numbers in brackets give numbers of crocodiles removed by Biology researchers before survey.

	GOOMADEER			WURUGOIJ			MAJARIE			NUNGBULGARRI			TOTALS			
	H	S	L	H	S	L	H	S	L	H	S	L	H	S	L	S/L
August 75	--	44	1	--	4	--	1	7	4	--	23	6	1	78	12	6.5
July/August/ September 76	18	23	11	--	--	1	--	5	2	2	10	3	20	38	17	2.2
June 77	2	41	7	NO SURVEY			NO SURVEY			2	10	2				
NO FLOODING																
July 79	29	49	12	--	2	7	--	13	5	10	16	9	39	80	33	2.4
HEAVY FLOODING																
June 81	6	30* (7)	7	--	3	3	--	11	8	2	21	4	8	65* (7)	22	3.0
October 81	17	25	3	--	7	1	--	12	5	--	22	3	17	66	12	5.5
DRY WET--MINOR FLOODING ONLY																
June 82	18	29	14	--	3	4	2	8	7	--	19	4	20	59	29	2.0
October 82	9	35	10	1	4	3	--	9	3	--	21	8	10	69	24	2.9

Table 7. Number of C. porosus sighted within the hatchling, small and large size classes on the major component tidal systems within the Maningrida monitoring area. *Numbers in brackets give numbers of crocodiles removed by Biology researchers before survey.

	Blyth-Cadell System			Liverpool-Tomkinson System			Rolling and Junction Bays			Totals			
	H	S	L	H	S	L	H	S	L	H	S	L	S/L
Aug/Nov 75	50	289	14	Data Unusable			1	78	12				
July/Sept 76	82	240	26	19	180	49	20	38	17	121	458	92	5.0
May/June 77	108	232	25	40	166	39	4	51	9+	152	449	73+	6.2+
October 77	112	226	22	56	147	25	No Surveys						
September 78	155	221	23	37	156	40	No Surveys						
NO FLOODING													
June/July 79	123	287	55	289	152	74	39	80	33	451	519	162	3.2
October 80	119	249	32	71	173	51	No Surveys						
HEAVY FLOODING													
June/July 81	76	253	37	26	176	54	8	65* (7)	22	110	494* (7)	113	4.4
October 81	72	204	39	34	166	54	17	66	12	123	436	105	4.2

Table 7. (continued)

	Blyth-Cadell System			Liverpool-Tomkinson System			Rolling and Junction Bays			Totals			
	H	S	L	H	S	L	H	S	L	H	S	L	S/L
					DRY WET--MINOR FLOODING ONLY								
June/July 82	136	205	67	193	207	67	20	59	29	349	471	163	2.9
Oct/Nov 82	111	19		144	171	69	10	69	24	265	437	132	3.3

+See Table 6; Majarie and Wurugoij Creeks were not surveyed thus resulting in the omission of a few small and large animals. Hence the value of S/L is probably slightly TOO LOW.

The Goomadeer River and Nungbulgarri Creek are both small TYPE 1 systems (note that Nungbulgarri was previously incorrectly classified as TYPE 2); the normal surveyable distance being 45.3 km and 14.8 km respectively. Hatchling recruitment on the Goomadeer, to date, has been relatively small, and on Nungbulgarri it has been almost negligible, even though both waterways contain some excellent nesting habitat. Upstream of the terminal survey points, both streams break up into a number of riverlets and semipermanent and permanent freshwater billabongs. These could provide limited alternative habitat for crocodiles excluded from the sections normally surveyed.

Wurugoij and Majarie Creeks are typical coastal hypersaline creeks--TYPE 3 systems--and hatchling recruitment on them is negligible. They do, however, act as temporary rearing stockyards for sub-adults and just mature adults excluded from the TYPE 1 systems nearby--the Goomadeer, Nungbulgarri, and the Liverpool-Tomkinson Systems, and one notes significant readjustment in numbers of both small and large crocodiles between the systems--compare for instance the results for the June and October 1982 surveys; some of the missing 23 (3-6') animals from the Liverpool-Tomkinson System could account for the increase of 10 small animals (mostly 4-5' and 5-6') sighted in the waterways of Rolling and Junction Bays.

Examination of Table 6 shows that within each of the four waterways there was substantial variation in the numbers of small and large *C. porosus* sighted during the surveys carried out between 1975 and 1982; for instance the number of non-hatchlings (small and large) sighted varied from 90 in 1975 to 55 in 1976, to 113 in 1979, to 78 in October 1981, and to 93 in October 1982. As we have pointed out on previous occasions (Monograph 1, Chapters 4 and 5, or see present main paper), the number of crocodiles sighted reflects well the number of crocodiles on the waterways and hence that the variations are usually real. These variations highlight further the highly dynamic situation which prevails on the tidal waterways--the movement within, into, and out of the waterways, the continuing loss of a very large fraction of the sub-adult population--and emphasize the need to consider broad groups of adjacent waterways over a period of a number of years, otherwise one could easily be misled by considering results for the survey only or from one or just part of one tidal system. Thus due care must be exercised when one attempts to draw conclusions from the survey data for Rolling and Junction Bay waterways alone. The number of small crocodiles sighted on these four waterways in August 1975 was 78, in October 1982 it was 69, with wide variations occurring for the intervening years. The number of large crocodiles sighted varied between 12 in August 1975 and October 1981 to 33 in July 1979. At best one may conclude that the population of non-hatchling *C. porosus* on these four waterways is remaining steady or increasing slowly, and that there is some slight indication that the size structure of the population is changing slowly with the ratio of small/large tending downwards.

ANAMAYIRRA, BEACH, CRAB, AND TOMS CREEK AND CADELL GARDENS BILLABONG

1. Cadell Gardens Billabong--October 31, 1982

This 2 km long billabong had been surveyed in October 1981, at which time four crocodiles were sighted in it, three EO and one 6-7'. The resurvey this year yielded three crocodiles, two EO and one 3-4'.

2. Toms Creek--October 25, 1982

This short (8.9 km) hypersaline coastal creek on the western shore near the mouth of the Liverpool River (Monograph 15, p. 133) was surveyed annually from 1976 to 1979 inclusive, but at no time were more than two non-hatchlings sighted. One resurvey this year yielded two (4-5') crocodiles and one hatchling only, again demonstrating that for reasons unknown, Toms Creek is not favored as a refuge for sub-adults excluded from the Liverpool-Tomkinson Rivers System. The creek is only slightly hypersaline (40%) and high fish activity--especially of mullet --was observed.

One hatchling was also sighted during the July 1979 survey of the creek. A helicopter survey was therefore made of the upstream sections of the waterway on October 28 and a number of possible nesting sites observed, but no old nests were sighted. It appears that there is some freshwater inflow into the creek, even at the end of the dry season, thus preventing the creek from becoming overly hypersaline. In 1974, one of the authors (H.M.) sighted two (3-4') crocodiles buried in mud underwater; the water in the shallow pond, beyond km 6, was only some 15 cm deep.

We have always experienced great difficulty in getting into or out of Toms Creek at night. During 1979, four separate attempts were made (at great cost) before the creek was surveyed. Our 1982 survey was made easier with the help of a helicopter to ferry in survey staff. However, Toms Creek lived up to its reputation on this occasion also; a 20-25 knot NE wind sprang up near the end of the survey making the return boat journey to Maningrida difficult.

3. Crab Creek--October 28, 1982

Utilizing vehicular access, Crab Creek was surveyed in November 1981 and again in October 1982. This is also a very short (3 km) shallow hypersaline creek and only the west arm is surveyable by dinghy at tide levels when EB >60 cm. Only two crocodiles (EO >6, >7) were sighted in November 1981 and one (EO >6) during the October 1982 survey.

4. Anamayirra and Beach Creeks--October 23-24, 1982

These two adjacent coastal hypersaline creeks are only some 10 km to the west of the mouth of the Blyth River and both could provide excellent alternative habitat for crocodiles excluded from it. The creeks were surveyed in July and again in October 1982. Sixteen non-hatchlings were sighted on Anamayirra Creek on both occasions (9S, 7L in July; 11S, 5L in October), whereas on Beach Creek six non-hatchlings (3S, 3L) were sighted in July and only three (3S) in October.

The survey results for the coastal creeks are somewhat surprising as one might have expected to have sighted more excluded crocodiles in them in October-November than in June-July. But this was not the case. The crocodiles missing from the Liverpool-Tomkinson and Blyth-Cadell Rivers Systems must have gone elsewhere (Milingimbi Complex?) or have been killed by the larger mature adults. Our finding, during the course of the October-November 1982 surveys, of the freshly dead (7-8') crocodile on the Tomkinson River and the sighting of a (7-8') *C. porosus* with one rear limb freshly torn off (see Cadell section notes) provides further support for the hypothesis that a substantial fraction of sub-adult or just mature crocodiles are killed by the larger animals.

BLYTH-CADELL RIVERS SYSTEM--NOVEMBER 6-8, 1982

1. Cadell River (Table 4)

Following the June 1982 survey of the Cadell River it was predicted, both for the Cadell and Blyth Rivers, that one could expect the number of small *C. porosus* sighted to remain essentially constant and for the number of large crocodiles sighted on it to decrease. These predictions have turned out to be correct for the Cadell, and as we shall shortly see, for the Blyth River as well. As may be seen in Table 4, 73 small crocodiles were sighted on the June survey and 71 on the October one. The number of large animals sighted decreased from 20 in June to 11 in November; the decrease occurring on the mouth sections of the Cadell River, precisely where the original increase from 9 in October 1981 to 20 in June 1982 had taken place. These crocodiles undoubtedly had come in and also left via the Blyth River at km 19.1. Not all of the missing nine large *C. porosus* are necessarily still alive; it is highly likely that a number of them have been killed by larger crocodiles. On the survey of the night of November 6, a (7-8') crocodile was sighted at km 45.9 (the breeding area) with a rear leg freshly torn off--obviously done by a larger crocodile.

The number of hatchlings sighted during the June survey was 51, whereas on the November survey it was 56. During the course of the latter survey it was noted that many of the hatchlings were very small, and hence a number of late nests had hatched since the June survey. No creches were seen.

The distribution along the Cadell River of small crocodiles changed between the June and November surveys. Whereas only 5S were spotted on the km 41.5-48.8 portion of the river in June, this number had risen to 12S for the November survey. The number of small crocodiles sighted on the km 19.1-29.1 section fell from 38 to 30, thus indicating that the small crocodiles were being forced upstream from the mouth sections of the river, perhaps by the remaining large crocodiles there.

2. Blyth River Sidecreeks (Table 4)

The number of both small and large C. porosus sighted on the sidecreeks of the Blyth mainstream decreased from the June to the November 1982 survey (Table 4). The number of small animals decreased from 14 to 9, and the number of large animals sighted decreased from 6 to 3. Though the number of animals sighted on the sidecreeks was small, the general decrease was indicative of the results found for the overall Blyth-Cadell Rivers System. It is interesting to note that the main decrease in small animals occurred on Creek B at km 3.5, near the mouth of the Blyth River where the concentration of large animals was greatest during the June 1982 survey. The decrease of three large animals in the sidecreeks also occurred near the mouth of the Blyth on Creeks B and C.

3. Blyth River Mainstream (Table 4)

The number of hatchlings sighted on the Blyth mainstream decreased from 84 for the June survey to 55 for the November 1982 one (Table 4). However the loss of hatchlings between June and November was greater than that implied by the difference between the two figures, for a number of very small hatchlings were sighted during the November survey, indicating that there had been an input of hatchlings since the June survey from late nest(s).

Though the number of small C. porosus sighted on the Blyth mainstream during the November survey (116) was essentially the same as on the June survey (118, see Table 4), their distribution along the stream had changed considerably. For instance on the km 0-10 mouth section, 19 small crocodiles were sighted during the June survey, whereas in November only 9 small animals were sighted. Small crocodiles excluded from the sidecreeks of the Blyth and from its downstream sections moved to what appears to always have been the most desirable sections of the mainstream, namely the brackish km 25-40 sections (Monograph 1, p. 334).

The extreme upstream sections of the Blyth mainstream which were surveyed in October 1980 (Monograph 1, p. 446) and June 1982 were resurveyed again November 1982. These are not included in our standard monitoring sections. Interestingly, on the km 49.8-59 section the number of small animals sighted had increased between June and November from one to seven and the number of large from three to four. Three large crocodiles were also sighted in the two billabongs between km 59-64.6. There is thus additional evidence that sub-adults are probably being excluded by the larger animals from the breeding sections of the waterway --especially during the breeding season.

The number of large animals sighted during the November 1982 survey had dropped to 26 from the 41 sighted in June 1982 and the decrease

occurred almost exclusively on the km 0-15 mouth section of the river--precisely on the same section where one of the major increases in large animals was observed between the October 1981 and June 1982 surveys. There is thus ever increasing evidence that substantial numbers of large animals enter and leave the Blyth-Cadell Rivers System via the mouth of the Blyth River.

4. Overall Blyth-Cadell Rivers System (Tables 1, 2, 3, and 4)

The 111 hatchlings sighted on the Blyth-Cadell Rivers in November 1982 can be expected to yield an input of some 80 (2-3') animals for the June 1983 survey. One might thus expect a major increase of this order in the number of 3-6' crocodiles sighted during future surveys. However, as may be readily seen from Tables 2, 3, and 4, this is not likely because of the continuing major losses (60-70 percent) of the sub-adults. It is difficult to believe that in October 1974 and again in November 1975 some 290 small C. porosus were sighted in the rivers system (Table 2), and furthermore that since that date there has been an input of some 800 hatchlings, and yet in November 1982 we sighted only 197 small (of which 154 were in the 3-6' size classes) and 39 large crocodiles!

The density and number of non-hatchling C. porosus sighted on the Blyth-Cadell Rivers System in November 1982 were smaller than on any other survey since they were begun in 1974. In fact, the number of non-hatchlings sighted in November 1982 was some 20 percent less than in October 1974. However, the data are readily understood in terms of our model of the dynamics of C. porosus populations given in Chapter 6 of Monograph 1. In fact, on the basis of this model, following the June 1982 survey, we predicted in our paper to the 6th Working Meeting of the SSC/IUCN Crocodile Specialist Group:

> "The October 1982 survey of the Blyth System may well reveal considerable readjustment between the increased number of small and large animals sighted on the mouth sections of both the Blyth and Cadell Rivers and show not only a small decrease in the number of large animals sighted on the overall Blyth-Cadell System but perhaps a further decrease in the number of small animals sighted as well. However, it is difficult to believe that the number of small C. porosus could decrease much further on the System, and it appears that a stage is being reached where the number of small animals sighted will commence increasing, but with the number of large animals increasing faster, thus yielding a decreasing, but fairly fluctuating ratio of small to large C. porosus."

As already discussed, a major readjustment did take place at the mouths of both the Blyth and Cadell Rivers which resulted in the redistribution of both large and small crocodiles along the two waterways and the loss of only 8 small but 28 large animals. The 72 percent increase from 39 large animals sighted in October 1981 to 67 in June 1982 had disappeared by November 1982 when only 39 large animals were sighted. Where did the animals come from and go to?

There is now little doubt that a major exclusion (including killing) and redistribution of both small and large C. porosus occurs during the breeding season which appears to commence around September-October (we do not know how long it lasts, perhaps right over the wet season), and it is during this period that the heavy losses of sub-adults largely occur. Some of the missing animals from the Blyth-Cadell System appear to leave it via the mouth of the Blyth River; others take up territory in less suitable habitat such as the extreme upstream sections of the Blyth and Cadell mainstreams. These "surviving missing animals" overall probably constitute some 15-20 percent of the non-hatchling population and apparently usually re-enter the main river system during the wet or early dry season, for it is usually the June-July surveys which reveal an influx, if any, of small and large animals. The remainder of the missing non-hatchlings from the normal annual recruitment simply must be presumed dead, and evidence is accumulating that mature C. porosus and sharks are probably responsible. The "missing, presumed dead" constitute some 60-70 percent of the non-hatchling population overall.

MONITORED MAJOR WATERWAYS IN THE MANINGRIDA AREA

In Table 7 we have assembled a summary of our survey results for the major tidal waterways monitored in the Maningrida area since 1975 in order to emphasize overall changes in the non-hatchling C. porosus population for a broad geographical area containing TYPE 1 to TYPE 3 systems. Comparing the results in the Totals column for 1976, 1979, and 1982, one immediately sees that the number of small crocodiles sighted has essentially remained constant, and that there appears to be a slow and small increase in the number of large animals sighted. Thus the ratio of small/large animals appears to be decreasing, but the fluctuations are substantial.

There is little evidence--other than in the changing size structure of the crocodile population--for a sustained recovery, and no evidence whatsoever for a major increase in the number of non-hatchling animals. From our model for the dynamics of a population of C. porosus we may predict--and the data support the model--that a major sustained increase in non-hatchling numbers must be measured in decades.

The results in Table 7 also show that the crocodiles missing from one large system are not necessarily compensated for by an equal increase in another large system nearby. For instance, the 28 large crocodiles missing from the Blyth-Cadell System in October 1982 did not result in an increase of 28 large animals in the Liverpool-Tomkinson System. Furthermore, as discussed elsewhere in these notes, there was no sign of an increase in the number of large animals sighted on either Crab, Anamayirra, or Beach Creeks which lie between the mouths of the Blyth and Liverpool Rivers. Where then can the missing 28 large crocodiles be? We can only guess: some already have been killed by larger crocodiles and/or sharks, and some may have migrated temporarily to the Milingimbi Complex, to the east of the Blyth River mouth. If this is so, then over the next few years we can again expect an influx of large crocodiles to the Liverpool-Tomkinson System and at the Blyth River mouth. It is still not clear what triggered the influx of large animals into the Blyth-Cadell and Liverpool-Tomkinson Systems in 1979 and 1982; however, the evidence is now strong that it was the 'dry wet' seasons preceding the surveys of those years.

ACKNOWLEDGEMENTS

The authors wish to thank the Science Foundation for Physics and the University of Sydney for their continued financial support. We also wish to thank the Aboriginal people in the Maningrida area for their help. Mr. Doug Martyn was our helicopter pilot and did all in his power to help us. Dr. Syd Kar, FAO Fellow from India, spent the survey period with us in order to learn our survey techniques. We wish him well with the C. porosus population in India.

MONOGRAPH SERIES

Surveys of Tidal River Systems in the Northern Territory of Australia and Their Crocodile Populations

A series of monographs covering the navigable portions of the tidal rivers and creeks of the Northern Territory. Published by Pergamon Press Ltd. (Sydney, Oxford, 1979-1982).

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CROCODILES IN THE REPUBLIC OF THE PHILIPPINES

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Crocodile habitat was never extensive in the Philippine Islands. Nowhere in the archipelago were the expanses of marsh or river habitats found in New Guinea or the southeastern United States duplicated. Limited crocodilian habitat coupled with an industrious human population, aggressively manipulating lowland habitats for basic agricultural necessities, has led to the virtual extinction of the endemic Philippine crocodile (Crocodylus mindorensis) and threatened the continued existence of the Indo-Pacific crocodile (Crocodylus porosus) throughout the Philippine Islands.

In 1980, the Smithsonian Institution/World Wildlife Fund Philippine Crocodile Project was initiated to determine the distribution, status, and conservation potential for the Philippine crocodile. Coincidental observations on the Indo-Pacific crocodile also were made. Funds for the SI/WWF project were exhausted early in 1982 and a final report on activities and findings was submitted to the IUCN/WWF in February 1982. The following is a summary of that report.

Distribution of the Philippine Crocodile

It now is not possible to determine the original distribution of the Philippine crocodile, owing to confusion between the two species of naturally occurring crocodiles and insufficient knowledge of their preferred or required habitats. Researchers cannot rely on early published accounts, verbal reports, or even recent reports, which are not verifiable now by museum specimens, artifacts, or photographs. That C. mindorensis is commonly called the "freshwater crocodile" and C. porosus the "estuarine or saltwater crocodile" has added confusion to this situation. Local languages do not differentiate between the two species with any certainty and even veteran crocodile hunters or crocodile skin dealers in some cases recognize more than two species. It is apparent that the habitat preferences inferred by the common names of these crocodiles have biased identifications in the past.

Distribution records suggest that the Philippine crocodile was widespread in the Philippine Islands. It is known to have occurred in

northeastern and central Luzon, Samar, Masbate, Mindoro, Negros, Busuanga, Jolo, and Mindanao Islands.

Few extant populations are known. Two individuals persist in the wild at the Pagatban River of southern Negros. These crocodiles are threatened by the activities of the local human population and by indiscriminant dumping of mine tailings into the river by a large copper mining operation. Another population known to have existed in the Kabankalan region of Negros Occidental is now extinct.

Three populations are known to still exist in Mindanao. These are in Zamboanga City, the Nabunturan area of Davao del Norte, and the Linguasan Marsh of Maguindanao and North Cotabato Provinces. In Oriental Mindoro, a juvenile crocodile was killed in 1981, but day and night surveys conducted in the area produced evidence of only C. porosus. It is probable that isolated disjunct populations or individuals still exist in northeastern Luzon and Samar. However, field work in these areas was limited owing to civil unrest.

Distribution of the Indo-Pacific Crocodile

The Indo-Pacific crocodile has been reported from Palawan, Cebu Province, northeastern Luzon, Mindoro, Catanduanes, and Mindanao. Field work indicates that C. porosus still exists in the Cagayan River drainage of northeastern Luzon (unverified report), Mindoro Oriental, Catanduanes, northern and southern Palawan, and Zamboanga del Sur, North Cotobato, Maguindanao, Agusan del Sur, Surigao del Sur, Surigao del Norte, and Bukidnon Provinces of Mindanao.

It is likely that C. porosus was more widespread than records indicate. Most extant populations are in freshwater palustrine habitats. If one assumes that this species utilized coastal habitats in the past, then its distribution in the Philippine Islands has diminished drastically.

Comments on Crocodile Distribution

In addition to previously mentioned areas, numerous other areas were surveyed either under the SI/WWF project or by the herpetological collection teams fielded by Silliman University, Dumaguete City, from 1958 to the present. Many of the smaller islands and islets as well as the larger Visayan Islands and Palawan were investigated. No crocodile populations were reported.

There is no evidence that C. mindorensis ever existed on Palawan. Many specimens of C. porosus from Palawan were examined, and veteran crocodile hunters active in Palawan in the 1950's report taking only the one species in the past. Crocodylus mindorensis undoubtably existed on some islands for which there are no records. Several islands surveyed under the SI/WWF project had habitat that would have been suitable for C.

mindorensis prior to agricultural improvements over the past 20 to 50 years, in particular the Visayan islands of Panay, Bohol, and Leyte.

Some areas that were surveyed where only C. porosus were visible may harbor undetected populations of C. mindorensis. In particular, the Agusan River drainage of central Mindanao deserves further work. It is known that the river, its tributaries, and the extensive freshwater marshes resulting from the annual flooding of the river are inhabited by C. porosus. However, some of the smaller marshy areas that have not been developed for agriculture at this time, and were not accessible to the SI/WWF project, may still have C. mindorensis. It is difficult to know which areas have crocodiles and impossible to prove which areas do not.

Natural History of the Philippine Crocodile

The largest C. mindorensis examined was a 3.5 m captive individual from Negros Occidental. The species matures at a small size. A 2.1 m, 47 kg male and a 1.3 m, 15 kg female C. mindorensis were observed to copulate, and the female subsequently laid eggs.

Crocodylus mindorensis has been observed to build a mound nest of vegetation and debris. Nesting occurs during the dry season, but varies according to locality. On Negros Island nesting occurs between March and July. Crocodylus mindorensis has been observed to guard its nest by lunging at human intruders and hissing. The species utilizes burrows.

The trail of a Trichosomoid nematode was observed on the ventral scales of a captive C. mindorensis.

Commercial Crocodilian Utilization

Little commercial utilization of native crocodilians occurs because local populations are depleted. Native crocodiles are still being hunted for skins in two localities in Mindanao: Tambulig District, Zamboanga del Sur, and the Linguasan Marsh area of North Cotabato and Maguindanao Provinces.

In Tambulig District, skins of C. porosus and live juvenile C. porosus are collected for export through the Sulu Archipelago to Sabah. In Cotabato City, skins of both species are collected and shipped to Manila for processing. In both areas coarse salt is used for preservation, and the skins regularly showed signs of putrefaction. The skins were poorly cut and the legs were not cut to maximize usable surface area. All skins had holes from careless skinning and were "3rd grade" by European standards.

The skins from Tambulig District were purchased by belly width. In Cotabato City skins were purchased by total length and the buyer paid hunters $US 7.75 per foot length. The skins were resold in Manila at $US 10.90 per foot length. The Cotabato City supplier/dealer estimates he

receives from 2 to 5 skins per month. In Tambulig District it is likely that more skins were traded per month, but no statistics were available as the dealer was reluctant to talk with us.

Processed skins and articles of both native crocodile species were seen in tourist shops and a tannery in Manila. The quality of tanning and manufacture of native crocodile goods is poor. Several tanned but whole skins of C. porosus were examined and several approximately 1 m skins of C. mindorensis were examined. We could not determine precise origin of these skins. Belts, shoes, and bags of both species can be purchased in tourist oriented shops for up to $US 90.00. Most of these items are reported sold to Australian and Japanese tourists.

In 1981, stuffed C. mindorensis were sold to Australian tourists for $US 100.00. Crocodile teeth, which are used for necklaces, were for sale in shops in Davao City, Cotabato City, and Manila. All were from small crocodiles; species identification could not be made.

A small trade in live C. porosus exists in Tambulig District. These live crocodiles were reportedly sold to dealers from the Sulu Archipelago through Zimboanga City and thence to Sabah through the "barter trade" routes.

Imported crocodilian goods are for sale to affluent Filipinos and tourists at some department stores and duty free shops in Manila. Articles manufactured from Alligator mississippiensis, Caiman crocodilus, Crocodylus porosus, and the southern New Guinea population of Crocodylus novaeguineae were identified.

Crocodile Farming

There has been interest in crocodile farming or crocodile "culture" for commerical purposes in the Philippines since early in the 1970's. The first crocodile farm of which we are aware was established in North Cotabato Province and reportedly housed nearly 500 crocodiles. These crocodiles were reported to have been slaughtered by the Philippine military around 1972. Since that time, the Soldana House of Reptiles has expressed interest in crocodile farming, but only recently has received a permit from the Ministry of Natural Resources for this purpose.

Over the past few years interest in crocodile farming has increased. The Forest Research Institute in Los Banos constructed a crocodile pen in Quezon Province, Luzon. They acquired a juvenile C. mindorensis from Mindoro Oriental which subsequently died from wounds received during capture. The pen was later dismantled.

A researcher from the Ministry of Natural Resources was sent to the United States for several months during 1980 to examine crocodilian farms. However, he apparently failed to make contact with any North American crocodilian researchers. The Ministry has since expressed a desire to establish a crocodile farm/sanctuary at Lake Naujan National Park, Mindoro Oriental. Crocodylus porosus still occurs in the area and a site adjacent to the lake that could be protected and serve as a crocodile ranch was recommended by the SI/WWF project to the Ministry.

The Japan Reptile Skin and Leather Association investigated the potential for large-scale commercial crocodile farming in the Philippines. A report on the Distribution and Breeding of Crocodiles in Southeast Asia was prepared by Mr. Koji Hara (Ueno Zoo) and presented to the government. However, negotiations between the Japanese and Philippine governments for the funding of a crocodile research facility and farm appear to have stalled. In part this may be due to the ratification of CITES by the Philippine government without a reservation allowing the trade in skins of C. porosus.

A crocodile survey of the Linguasan Marsh area of southern Mindanao was funded by the government. The survey was conducted by the Silliman University Environmental Center with technical aid from the SI/WWF project. Its purpose was to determine the identity and status of crocodiles occurring in the area and the potential for crocodile utilization for national livelihood programs. The conclusion of the Silliman University study was that "a crocodile industry based solely on collection of wild crocodiles for rearing and eventual slaughter for skins is not feasible" in southern Mindanao owing to a scarcity of crocodiles.

Silliman University started a crocodile breeding project with aid from the SI/WWF project and financial support from WWF in 1980. The first known nesting of C. mindorensis in captivity took place during 1981. All but two eggs were infertile and no young survived. Fourteen C. mindorensis were successfully hatched in 1982. The university now has three adult C. mindorensis, and a single C. porosus.

Crocodile Conservation

Three supposedly protected areas have extant crocodile populations; however, actual protection of crocodiles does not occur. They are Lake Naujan National Park, Mindoro Oriental; Linguasan Game Reserve, North Cotabato and Maguindanao Provinces; and the province of Palawan.

At Lake Naujan, fishermen catch young C. porosus on fishing lines and large animals are killed in nets. Crocodiles occur only in the restricted zone of the park, and in theory should be under protection. However, the government has neither the required personnel nor equipment to effectively patrol the area. Fishing is intense and crocodiles continue to be killed. There is a conflict between preserving the national park for wildlife and development of the area for commercial and subsistence level activities by the local residents.

The Linguasan Game Reserve is by law a protected area. Over the past decade there has been little law and order in the area. It is highly

dangerous for government personnel to enter. The continuing civil unrest has effectively preserved the marsh lands and some crocodiles, although it is evident that rice lands are steadily encroaching crocodile habitat. For many years there has been a plan to drain the swamp for agricultural expansion. But civil unrest caused this to be postponed.

The entire province of Palawan has been declared a protected area. However, like Lake Naujan and the Linguasan marsh, the crocodiles receive no protection.

Sumalig Island of Tambulig District, Zamboanga del Sur, has been proposed as a crocodile sanctuary by government agencies. Inhabitants of the area previously sold skins and live juvenile C. porosus. However, there is no longer a village on the island and the crocodiles are effectively protected for the time being.

The largest crocodile population remaining in the Republic of the Philippines is in the Agusan River drainage of Agusan del Sur near the Davao border. This area is sparsely populated by people due to the extensive annual flooding of the Agusan River. Although influenced by political dissidents, the region is still relatively peaceful. Because of natural phenomena and conflicts between the government and militants the area cannot be effectively protected as a national park. The area could act as a sanctuary for C. porosus if local inhabitants and militants were convinced that they could ranch or crop crocodiles on a sustained yield basis. At present, any crocodile encountered is killed, and if it is a nesting female the eggs are destroyed. There appears to be no commercial utilization of skins at present.

Silliman University plans to release captive propagated C. mindorensis into sanctuary areas. However, no suitable areas have been identified and the captive breeding program is still embryonic.

There is little future for crocodiles in either existing or proposed sanctuary areas. Agricultural pressure on crocodile habitat is intense, and with the exception of Palawan, areas with remaining crocodile populations have civil peace and order problems. If sanctuary areas are relied upon for the conservation of crocodiles, both C. porosus and C. mindorensis will become extinct in the Philippines. Until such a time as public sentiment and awareness for wildlife preservation permit reintroduction of the species into secure sanctuary areas, the Silliman University crocodile breeding project is the only hope for preserving C. mindorensis. Commercial exploitation of C. porosus may prolong its survival in the wild in some parts of central Mindanao.

CONCLUSION

Conservation of non-essential natural resources is not a high priority of the Republic of the Philippines. The Philippines is a rapidly developing country that, through an active government policy and owing to the industrious nature of her people, is rapidly modifying or utilizing all accessible natural resources for socio-economic improvement. The government is aware of the value of natural resource conservation. Several large government sponsored or run programs are now in existence trying to develop criteria for the rational utilization of mangrove, water shed, and forested areas. However, when the conservation of natural areas or preserves, or in this case a wild species, interferes or has the potential to conflict with high priority government goals dealing with human settlements or livelihood programs, the socio-economic improvements of the local human population will have priority. This is particularly true when dealing with wildlife species, such as crocodiles, which elicit little sympathy and are feared as a predator of man and his domestic animals. How do we integrate a policy of preservation of an animal which is potentially dangerous, disliked, and lives in areas suitable for fish ponds and rice paddies? The government of the Philippines is interested in how crocodiles can benefit the people, not conservation of a non-commercial natural resource. The future for crocodiles in the Philippines, and probably the remainder of southeastern Asia, is bleak.

STATUS OF THE CHINESE ALLIGATOR IN THE PEOPLE'S REPUBLIC OF CHINA

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The Chinese alligator population is plummetting toward extinction, a victim of human population pressure and man's prejudices. Once widespread throughout the eastern portion of the Yangzi River basin, the alligator is now limited to approximately one-tenth of its former range, a mere 25,000 km^2 (Fig. 1).

In 1981, under the auspices of the Chinese Academy of Sciences and the U.S. National Academy of Sciences Committee on Scholarly Communication with the People's Republic of China, we began a joint Chinese-U.S. study of the ecology, behavior, and distribution of the Chinese alligator. In 1982, this study was continued by Mr. Huang and Prof. Shi Yingxian of Institute of Developmental Biology, Chinese Academy of Sciences.

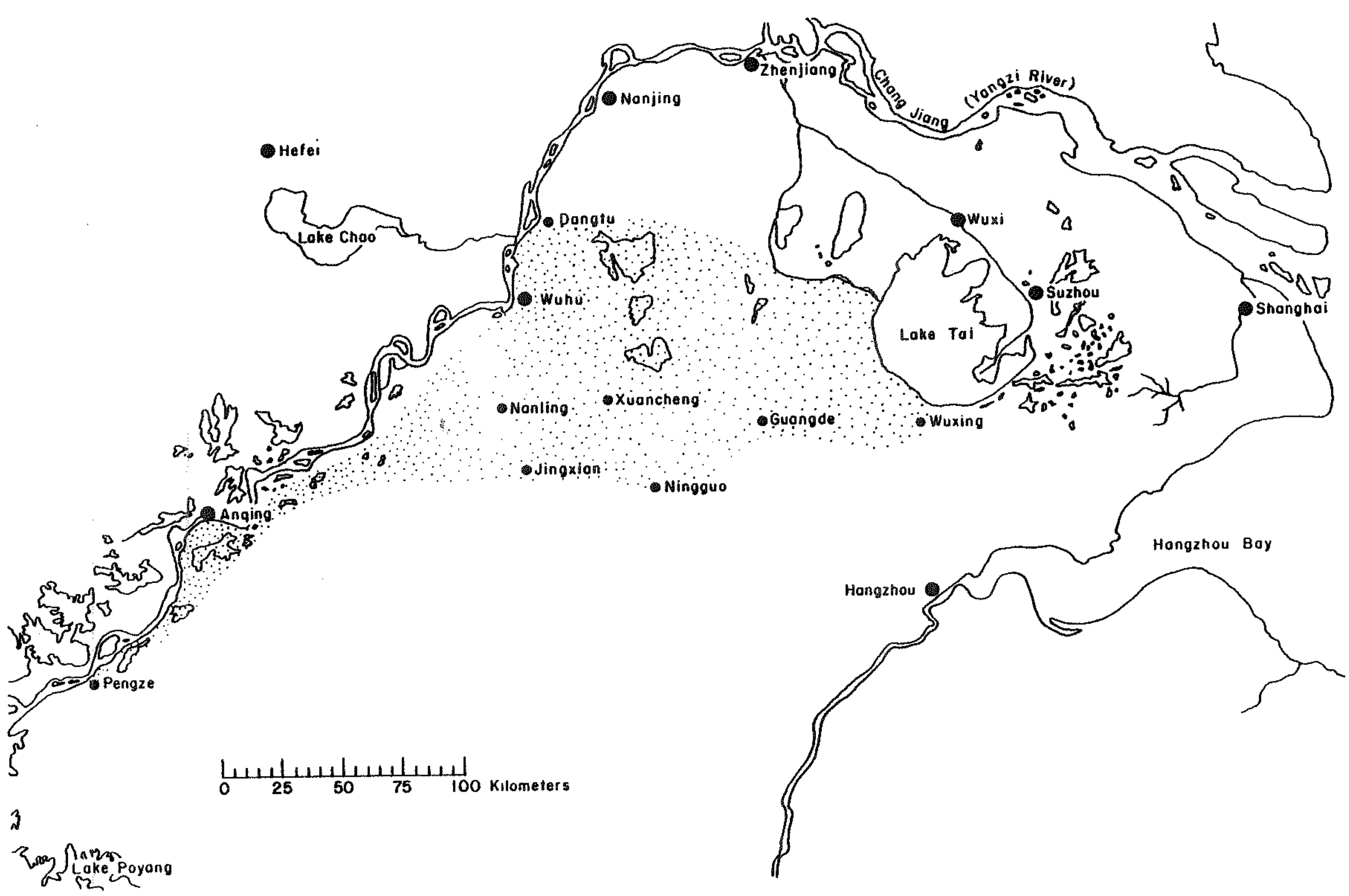
The area visited in 1981 encompassed a wedge-shaped region approximately 60 km on the long axes and extending from Jingxian County to the border of Ningguo County with the city of Xuancheng (118°45'E 30°57'N) at the apex, a total area of approximately 2,800 km^2 or 11 percent of the current range of the Chinese alligator.

Ecology of the Alligator

The alligator is active from late April or early May through October, hibernating in its underground den the rest of the year (Huang 1978, 1981, 1982; Groombridge 1982). Animals commence basking in the spring, a behavior that is frequently interrupted by man's activities. When children are out of school during lunch hours and on Sundays, they throw projectiles at basking animals. Water buffalo and their riders indulging in afternoon swims near basking sites also disturb the alligators. Thus frightened, the alligators return to their dens or hide under overhanging vegetation.

Figure 1. Current habitat of the Chinese alligator (stippled).

Regions visited for this study included Xuancheng, Nanling, and Jingxian.



Alligator activity centers around the den. Not only do animals remain hidden from view when disturbed, but they remain in their dens on cool (less than 25°C), very hot (near 40°C), windy, or rainy days. Although males wander away from the dens during breeding season in search of mates, females and their young of several age classes remain sufficiently near to flee to the dens' relative safety and stable temperature. Earlier studies (Chu 1957; Chen and Li 1979) showed two den types: simple and complex. Simple dens have one or two rooms, one of which may have an underground pool. Complex dens may be made up of many rooms. One den complex continued for more than 50 meters and included both above-ground and underground pools. Dens may be readily located due to the presence of numerous airholes that are excavated from the den chambers up to the substrate surface. Although it has been suggested that complex dens are inhabited by more than one animal, and the size and structure of the den is determined by the age and sex of the inhabitants (Chu 1957; Chen and Li 1979), there are few data to support these contentions. As simple dens were seen in farmed areas, and complex dens in "wilder" areas, it is possible that den structure may be related to amount of space available, to substrate type, or to the length of time it has been actively occupied. This needs further investigation.

Courtship and mating occur from early to mid-June. Bellowing may signify locations, sizes, and sexes of animals and may aid potential mates in locating each other.

Courtship consists of snout-touching, "chuffing" vocalizations, and, if not broken off in the early stages, submerging and resurfacing, often followed by snout lifting. Mounting ensues. Successful mounts are characterized by the male positioned slightly laterally on the female's dorsum, his tail wrapped around and under the female's tail so that the vents may meet. These mounts last for approximately 15 minutes.

Nesting occurs in mid-July, one month after copulation. Nests are typical crocodilian mound nests of scraped-together vegetation, predominantly bamboo. Between 10 and 40 (Huang 1982; Groombridge 1982) eggs are laid in the nest.

There is evidence that the female guards the nest, but not diligently enough to deter children from overrunning nests and destroying the eggs within.

Eggs hatch in late September approximately 70 days after oviposition, just in time for hibernation to begin.

Habitat

On-site investigations indicate the Chinese alligator occurs in three categories of habitat: (1) riverine and swampy areas, (2) sea level or nearly sea level agricultural communes, and (3) tree farm communes with reservoirs up to 100 m above sea level. Habitat types may

be further subdivided based on studies of remote sensing imagery for that region (Watanabe and Huang 1982; Watanabe, Walker, and Huang 1982).

Riverine and swampy habitats historically were similar to those regions inhabited by the Chinese alligator's nearest relative, the American alligator, Alligator mississippiensis. These were typical crocodilian-inhabited wetlands. The swamps, such as the Yunmeng Swamp (Huang 1982) in Hubei Province have been drained and reclaimed for agricultural use and are no longer suitable for alligators. Rivers are heavily polluted and silted. Most of the remaining riverine alligators were drowned in their dens during severe floods in 1957. Thus, what should be prime habitat is essentially devoid of alligators. In heavily agricultural regions, animals reside in dens built into the banks of irrigation streams, often adjacent to cultivated fields or even behind houses. Some animals even live in narrow earthen dikes between flooded rice fields. This agricultural habitat is less than prime. The human population is very dense and interactions between humans and alligators are frequent. Commune members know where each alligator lives and the habits of each animal. Unfortunately, this renders the animals vulnerable, and, periodically, local people dig one of these alligators out of its den. The hapless animal may be killed, its body left to rot or chopped up for duck feed, or sold to dealers for unscrupulous zoos. Although there are rumors that hides have entered into the international market, these rumors are, to date, unfounded.

The third habitat type, higher than sea level tree farm communes, is home to Chinese alligators solely because of the presence of reservoirs which are adjacent to underground water supplies. During drought, the animals leave their reservoirs in search of water, but they have no place to go. Heading uphill would lead them to cooler mountainous regions in which they could not survive. Downhill will lead them into less than prime, heavily populated human habitat. Thus, the higher altitude reservoir habitat is the last refuge of the Chinese alligator.

Even here, the alligator is not safe from man. We found dens only days after they had been destroyed by local people who had removed the resident animals. While searching for dens we were followed by peasants, some anxious for information on den locations.

Conservation Measures

Officially, the Chinese alligator is classified as a "number one category endangered species" (Huang 1978, 1981, 1982), the same classification as the giant panda. On paper, the communes in southern Anhui Province have been set aside as alligator preserves, but heavily populated working agricultural communes have neither the staffs nor the resources to protect the alligators from harassment, removal, or killing by the local inhabitants. Protection is minimal. It is illegal to capture and kill animals, but there is no enforcement.

On only one commune visited in 1981 was there a sign declaring the Chinese alligator to be a protected species. A poster exhorting people to protect the animal was seen at Anhui University in Hefei, the provincial capital, which is outside the range of the alligator. Posters were seen on none of the communes in southern Anhui. Although local officials spoke of the possibility of education campaigns among the local citizens, such campaigns are expensive with results slow in coming, and so have not been initiated.

The Xiadu Alligator Farm was established several years ago in Xuancheng County in Southern Anhui Province, under the auspices of the Prefectural Forestry Bureau. Nine adult animals were maintained there until the first pools and buildings were completed in May 1981. Since then, the farm has affected the local alligator population negatively. Local people, hearing that the farm would pay for animals, caught wild alligators in their dens and carried them to the farm for sale. Reportedly, the farm offered Y100 (U.S. = approx. $66) for any animal over 40 jin (= approx. 0.5 kg) in weight. A wild animal of that weight would measure close to the species' maximum of two meters in length. Some communes, holding recently captured animals of close to, but under 40 jin requested more than Y100. When the farm refused to pay them that amount, the communes refused to transport the alligators to the farm. Presumably, these animals were left to die. By late July 1981, the farm population had increased to 89 alligators, all but one of which were adults. On 13 July, when the farm had 80 animals, only 16 were male. By summer 1982, the farm housed between 130 and 140 alligators. The farm was not designed to handle so many animals. As of 1981, it had three large pools: two wedge-shaped, concrete and stone lined pools approximately 10 m by 10 m on the straight axes and 15 m on the rounded edge, connected by a filtration system, and a larger doughnut-shaped pool. In the wedge-shaped pool, maximum water depth was one meter.

One pool had a door with a double sheet of glass in it so that the activity in the pool could be viewed from an adjacent concrete room. The room itself was to be used to maintain some animals during winter hibernation. Water inflow was via a bamboo pole. Water was pumped from an uphill reservoir by a portable gasoline engine. The drain was a small grate in the wall slightly above floor level. It was readily clogged by dead fish, live ducklings, or debris.

The doughnut-shaped pool was designed as a display and breeding pool. It was approximately 30 m in diameter, with an approximately 20 m in diameter island in the center. Surrounding the island were concrete conduit pipes. Some animals immediately established their territories in the pipes. The remaining animals (more then 60 were in the pool in July 1981) hid in rock crevices or congregated under a temporary bridge the workers used to travel back and forth to the island. The sides of the pool were of concrete and rock; the bottom of mud. Maximum water depth was two meters. Water inflow, as in the other two pools, was through a bamboo pole. The outflow was one small circular drain placed in the side

wall. A *Chinemys reevesi* turtle became stuck in the drain and prevented all water outflow.

Plans for the farm included planting the center island with bamboo and erecting a two-story laboratory building above the filter system between the two wedge-shaped ponds.

Immediately after the first animals were placed in the wedge-shaped pools, farm officials were informed of the abrasive properties of concrete on crocodilian skin, especially concrete made from construction sand (Potter, Bacon, and Watanabe ms.). By early July, many of these animals had concrete-induced lesions. Farm personnel then resurfaced the pools with smoother concrete.

In 1981, the farm had two additional structures: a dormitory and kitchen building and a second dormitory building that also included a meeting room and a guest room.

Two "semi-natural" ponds were dug in an area fed by an underground stream. Both pens were irregularly shaped and very small, the pool of one measuring about five meters by three or four meters with several meters of dry land adjacent. As many as seven gravid females successfully escaped from one pond and only one of these females was located by late July. As the farm supports no natural alligator habitat, and is several kilometers uphill from the Xuancheng River, which, during the dry season is made up of disconnected puddles, animals escaping from the farm would not be likely to reenter the wild population. The semi-natural ponds were on the main pathway and adjacent to the waterhole that was the only source of water for human use at the farm. Thus, the animals were disturbed at all hours of the day and night.

In 1981, one female at the farm laid eggs. She released them in the water in one of the semi-natural ponds, and they were not found until several days after oviposition. A second female was induced to lay one egg by injection of oxytocin.

The farm was not equipped to incubate eggs. However, local people brought eggs in shoulder-slung baskets or in their pockets for sale to the farm, which paid them Y1.00 (U.S. $.66) per egg. Banded eggs, unbanded eggs, and eggs that had been rotated were purchased. Eggs were set up in straw baskets, or crockery or rubber basins on the concrete floor of the guest room. Protocols for care of eggs during incubation were given to farm personnel, but they were not followed. Of more than 200 eggs incubated at the farm in 1981, approximately 40 young hatched and 24 survived until hibernation. Eighteen of these young came out of hibernation in the spring, but all died before summer. Chen Bihui (pers. comm.) reported an 86 percent hatchling success rate at the farm in 1982 but he did not report numerical data.

The farm has no facilities for young animals.

The farm is run by the director of the Prefectural Forestry Bureau. Several wildlife technicians are on the staff. Only one staff member has any wildlife management background. He is a graduate of the local agricultural college.

The farm was designed and built without assistance or input from any person or organization experienced in crocodilian farming. No one from the farm visited the Swatow Crocodile Farm in Southern China, which was established with the assistance of Utai Yangprapakorn, proprietor of the Sumatprakan Crocodile Farm in Thailand and who is known to Chinese authorities as Mr. Yang.

The staff had no training or experience in the operation of an alligator farm. Animals were fed fresh fish and ducklings several times per week, but food quantities were not monitored and food not consumed was allowed to rot in the pools. Pools were overstocked and rarely cleaned. Although animals were tail-clipped and data on length, weight, sex, and location of capture were maintained, pools were stocked haphazardly with no consideration for the animals' sexes or sizes.

Eggs were weighed, measured, and marked, with the width of the white band clearly delineated, but eggs were not kept moist, and incubation temperatures and band width changes were not monitored.

Problems were further compounded by the lack of technology. Simple items such as thermometers, plastic bags, wax pencil or permanent ink markers, and insulated styrofoam boxes are unavailable. No one at the farm could read any language other than Chinese, so instructional and scientific materials must first be translated.

Farm personnel are responsible for enforcement and guarding the habitat at communes within the prefecture. Donghe Commune in Nanling County had more than 28 alligators, many of which were badly harassed by people. From the time we left Anhui in late July 1981 until July 1982, when one of us (CCH) returned to the commune, Donghe had not been visited by farm personnel. In the past, every two years at least one nest at the commune hatched successfully. In 1981, all eggs were removed and sold to the alligator farm. Thus, the farm was serving as a stimulus to remove animals and eggs from the remaining habitat, and was maintaining the animals in a captive environment where husbandry was less than adequate and where there was little chance for reproduction. Recent articles in the Chinese press accused the farm of becoming an "alligator crematorium" (Anon., 1982).

Mr. Chen Bihui of Anhui Teacher's University in Wuhu is scientific advisor to the farm, though he spends only a few days per year there.

If given a properly trained staff and some small amounts of technology, it is possible that the situation at the Xiadu Farm could be changed. There is sufficient area (89 hectares now, to be expanded to 3,335 hectares) and enough manpower to run an effective farming operation. But without aggressive lobbying of the Central Chinese Government from outside conservationists, and, especially, agitation to allow continuation of collaboration with experts knowledgeable in crocodilian farming procedures, the farm and, unfortunately, the entire alligator population of southern Anhui Province are doomed. The Central Government is genuinely interested in conservation of the alligator but the Xiadu Farm is under local control.

Fortunately, two captive breeding facilities are being established in Zhejiang Province with the full cooperation of the Zhejiang Provincial Forestry Bureau and with the professional assistance of one of the authors (CCH) and Prof. Shi, an embryologist.

Although several Chinese zoos have Chinese alligators, only the Shanghai Zoo has successfully bred the animal in captivity. In spring and summer, alligators are maintained in a semi-natural pond outside of the public areas. In 1980, twelve young were hatched and in 1981, seven young were hatched.

The Beijing Zoo has about 34 Chinese alligators in an indoor enclosure suitable for less than a third of that number. In 1981, one egg was found, but it did not develop. They plan to build an outdoor quasi-natural breeding pond. The Reptile House staff at the Beijing Zoo is extremely well experienced and competent and is anxious to give the animals the best situation possible. One of the authors (CCH) and Prof. Shi are advisors to the Beijing Zoo on this project.

SUMMARY

The picture for wild populations of the Chinese alligator is bleak. Based on the number of animals known to us in the Xuancheng region--63--and the increase in the farm population from nine to 89 individuals, all but one of which were adults and only one or two of which were counted among the 63 animals we knew of, within two months, we estimate that the alligator population of the Xuancheng region must be in the range of 300-500 animals. Most of the animals we knew of were juveniles, and we suspect the population is heavily skewed toward younger age groups. No area in the Xuancheng region is "wild." All are heavily influenced by humans. Alligator inhabited regions in Zhejiang and Jiangsu Provinces supposedly support smaller populations than Xuancheng. Thus, we estimate China's total alligator population, including animals at farms but excluding animals at zoos, to be, at most 1500-2000 individuals. Refined censusing techniques are necessary for more accurate figures.

Continued capture and killing will further reduce the population. Unless husbandry procedures are drastically revised, capture of animals and collection of eggs for sale to the Xiadu Alligator Farm will ensure that there will be little successful reproduction, and the mature animals will be subjected to improper care.

Natural phenomena, such as floods, may be expected eventually to destroy the entire wild population living in the human modified habitat on sea level communes. Drought could destroy the remaining alligators in all habitats.

Barring any extremes in natural conditions, we hypothesize that the Chinese alligator will be extinct in the wild by the early 1990's.

ACKNOWLEDGEMENTS

This paper is based on reports by MEW to the U.S. Fish and Wildlife Service and the Fauna and Flora Preservation Society.

MEW's work was carried out under an Advanced Research Fellowship from the National Academy of Sciences, Committee on Scholarly Communication with the People's Republic of China, and with grants from the Office of Endangered Species, U.S. Fish and Wildlife Service; The National Geographic Society; The Explorers Club; the Society for the Study of Amphibians and Reptiles; and the Fauna and Flora Preservation Society.

We thank the Institute of Zoology, Chinese Academy of Sciences, Beijing, for its cooperation.

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THE U.S. TRADE IN CROCODILIAN HIDES AND PRODUCTS, A CURRENT PERSPECTIVE

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ABSTRACT: With the deregulation of the American alligator in 1979, and subsequent changes in state regulations, a promotion to re-introduce the "alligator look" was initiated. Untanned hides were exported out of the U.S., primarily to France and Italy. The fashion appeal was short-lived and has been largely replaced by quality leather of domestic species.

The crocodile leather and products industry in the United States has gone through a significant metamorphosis over the past ten years. Products made from the hides of the American alligator (Alligator mississippiensis) and exotic species such as the Nile crocodile (Crocodylus niloticus) carried with them a mark of distinction and affluence, while hides of caiman were used to produce stuffed trinkets, cheap belts, shoes, and watchbands. By 1970, many of those species most prized for their hides had suffered from over-exploitation and experienced dramatically declining populations.

A campaign to protect crocodilians was launched in an atmosphere of genuine concern for the environment. It was well received by governments, wildlife organizations, and the general public. The phrase "Endangered Species" came into everyday use. In 1973, the Convention on International Trade in Endangered Species afforded some protection for nearly all species of crocodilians, although the countries that processed most of the crocodilian hides for the world market either refused to sign the agreement or took exception to the inclusion of the crocodilian species they utilized. The U.S. Endangered Species Act was also passed, and for some forms, such as Caiman crocodilus yacare, provided total protection, although CITES listed the species on Appendix II. Many states followed and adopted the Federal and International lists into local wildlife regulations. New York State had already taken the lead with the passage of the Mason Bill in 1971. It totally prohibited the sale or possession for sale of all crocodilians and their products. This measure was enacted only after a lengthy battle with representatives of the crocodilian leather industry.

New York law was significant, in that more than 80 percent of the U.S. commerce in crocodilians passed through the Port of New York City.